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The Engineer

VOL. CLXXVI—No. 4590 | 28, ESSEX ST., STRAND, LONDON, W.C.2 | DECEMBER 31, 1943

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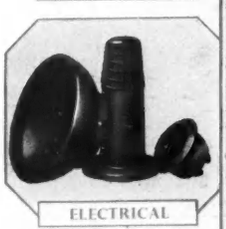
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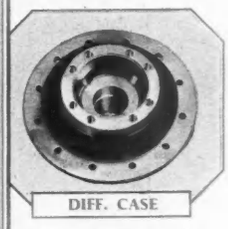
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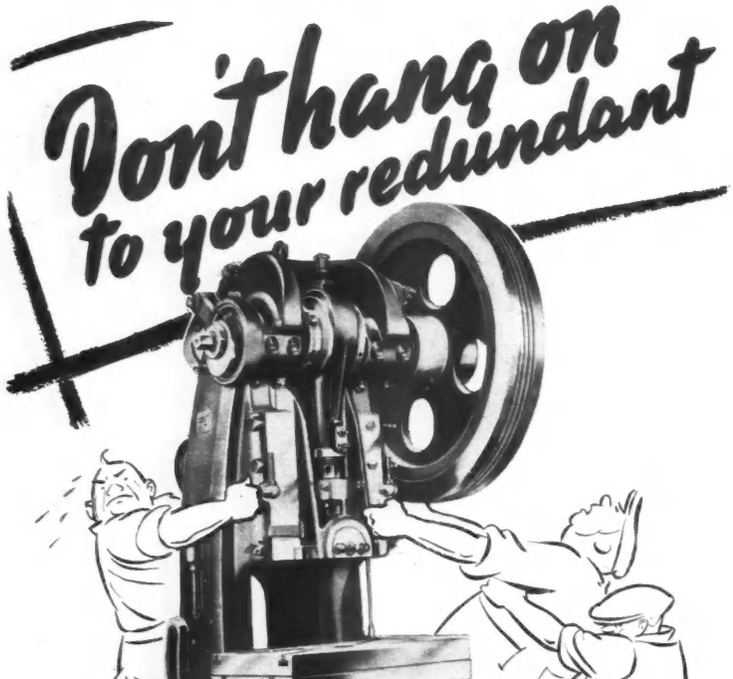

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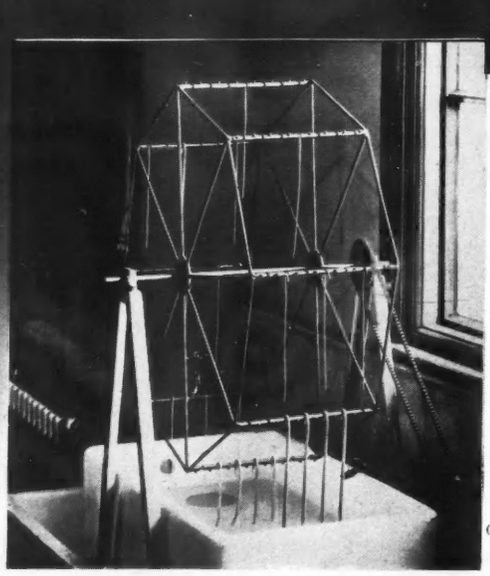

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the benefit of applicants, the Proprietors epared to insert brief notices that vacancies filled, upon receipt of notifications from the ertisers. These notices (limited to one line) be free of charge, and co-operation is ed for.

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The Engineer

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For continuation of Small Advertisements see page 50

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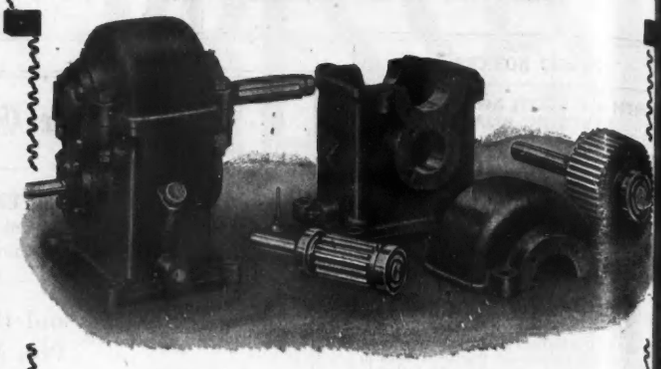

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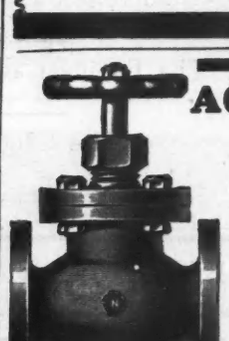

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A Seven-Day Journal

The Sinking of the "Scharnhorst"

ON Sunday night, December 26th, it was made known by the Admiralty that the German battleship "Scharnhorst" was brought to action by units of the Home Fleet, which were covering a North Russian convoy, under the command of Admiral Sir Bruce Fraser, K.C.B., K.B.E. The action took place on Sunday afternoon, and the "Scharnhorst" was sunk off the North Cape on Sunday evening. According to an account made public by the Admiralty on Tuesday, December 28th, the "Scharnhorst" was trapped between two formations of British ships, one, with the convoy, including the cruisers "Belfast," "Norfolk," and "Sheffield," and the other, further afield, including the new battleship "Duke of York" and the cruiser "Jamaica." Whilst endeavouring to escape at high speed in the Arctic night the enemy ship was attacked with torpedoes by our destroyers and so damaged that her speed was reduced, permitting the "Duke of York" to come up and finish the action. The "Scharnhorst," under the command of Captain Hintze, sank with her colours flying towards 7.30 p.m. The "Scharnhorst" and her sister ship the "Gneisenau" were designed and built as a reply to the French battleships "Dunkerque" and "Strasbourg" and were laid down in 1934 and completed in 1939 and 1938. The "Scharnhorst" had a displacement of 26,000 tons, with a water line length of 741ft. 6in., a beam of 98ft. 6in., and a mean draught of 24ft. 8in. Her ship's complement of officers and men was about 1461. Her armament comprised nine 11in. guns, twelve 5·9in. guns, along with fourteen 4·1in. and sixteen 37 mm. anti-aircraft guns. The armoured belt amidships had a thickness of 12in. to 13in., and it tapered to 3in. to 4in. at the ends; 12in. armour was employed on the turrets and 6in. armour was used on the decks. Four aircraft were carried, along with two launching catapults. The propelling machinery consisted of a three-shaft arrangement of geared turbines taking steam from high-pressure water-tube boilers. Oil engines were used in combination with the steam turbines at cruising speeds. Although designed for a speed of 27 knots, the actual full speed was believed to be about 29 knots. The "Scharnhorst" and "Gneisenau" took part in some naval engagements and Atlantic raids. They had to take refuge in Brest and were heavily bombed by the R.A.F. In February, 1942, the two ships steamed through the Channel in misty weather and reached Germany. Later the "Scharnhorst" joined the "Tirpitz" in Norwegian ports, while the "Gneisenau" is, it is believed, still under repair in a Baltic port, probably at Gdynia. Among the larger ships of the German Navy there only now remain the "Tirpitz," the heavy cruisers "Hipper" and "Prinz Eugen," and the armoured pocket battleships "Admiral Scheer" and "Lutzow," all of which are supposed to be in Norwegian or Baltic waters.

British Railways in Peace and War

NEW facts about the railways are revealed in the publication "British Railways in Peace and War," which will be available to the public (price 1s.) early in the New Year. During the period between 1923 and 1942 the British railways spent £450 million on new works and reconstructions. Of this sum, £170 million was spent on new engines and rolling stock, and 23,000 miles of track were renewed. During wartime engines have travelled 1870 million miles to haul trains 1265 million miles. In 1942 passenger travel totalled 30,000 million miles, an increase of 50 per cent. on pre-war, and at the same time the mileage run by passenger t[illegible]ns decreased by 28 per cent. The miles [illegible]y loaded goods wagons in 1942 totalled [illegible] million, or 32 per cent. over peacetime. [illegible] same number of miles were run in 1938 as in 1923, but with 4300 less locomotives; between 1923 and 1938, 350 new stations and 40 new goods depôts were provided; £7 million was spent on new steamships, and a £40 million programme for London was commenced. Some further details are given of the effects on the railways of 10,000 attacks from the air since the beginning of the war, and how the trains were got through. Up-to-date figures of the staffs employed by the railways indicate that 114,000 women are at work out of a total of 668,145. Over 110,000 men and women are serving in H.M. Forces and in full-time civil defence. As to the war effort of railway steamships and marine staffs, ninety-two railway vessels have been chartered by the Government for service as hospital carriers, transports, assault ships, minelayers and sweepers, ammunition carriers, anti-aircraft ships, and rescue ships sailing with Atlantic convoys. A review of the railways' air services discloses the fact that during the three years ended June, 1943, the companies associated with the railways have operated over 4,000,000 aircraft miles, conveyed 163,000 passengers and 4,000,000 lb. of urgent mail and goods. The review concludes with a consideration of plans for the post-war development of electrification and other matters.

Mersey Dock Improvements

AT the annual meeting of the Mersey Docks and Harbour Board, which was held in Liverpool on Wednesday, December 22nd, Sir Thomas Brocklebank, the Chairman of the Board, said that considerable progress had been made with the three-year reconstruction plan for the docks. Meetings between the dock officials and the railway companies serving the port had been held, and a scheme had been prepared which would greatly improve the working of the port. It was proposed to construct an entirely new deep-water entrance to the Canada dock system, which would enable the Board to replan the Langton, Brocklebank, and Canada docks, so as to provide new sheds and wide quay margins with up-to-date cranes and equipment. It was also planned to construct two new sheds at North Huskisson No. 1 and South Huskisson No. 3, and a new meat berth, with the best possible rail and road facilities. Additional railway sidings, which had long been needed, would also be provided. It was also proposed to proceed at the earliest possible moment with the completion of the Waterloo river entrance, on which work had been suspended owing to the war. In addition to those new and important works, all of which, Sir Thomas said, ought to be proceeded with concurrently, there was also a lot of equipment on the dock estate, much of which fell due for renewal prior to the war and which now called for early replacement. Since 1939 the docks had been called upon to handle frequently monthly volumes of cargo greatly in excess of what they did in normal times, and this had been done under wartime conditions, with all their attendant handicaps. It seemed to the Board both improvident and unwise to contemplate at this time any large extensions or additions to the dock area, and the policy was to do everything in the Board's power to improve the existing dock system by modernisation.

The "Heinkel 177" Bomber

THE Air Ministry has recently released certain interesting particulars with regard to the design and equipment of the new "Heinkel 177" bomber, which, after considerable experiment, has now appeared as a long-distance sea reconnaissance aircraft and long-range bomber. The output of these machines would seem to be small, but a few of them have been met with in Western Europe. The new aircraft has a wing span of 103·5ft., which is about 2ft. more than that of our own "Lancaster" bomber. The wing is of all-metal construction, with a parallel centre section and tapering outer panels. The fuselage is of rectangular section with rounded corners, and the tail unit has a single fin and rudder of angular appearance. The present version of the bomber has 13 mm. guns, which are fitted in the nose, dorsal, ventral, and tail positions, and the bombs are carried internally. A top speed of about 130 m.p.h. is mentioned. The undercarriage has two main landing wheels on either side, and these are retracted into the wings, so that with a raised undercarriage two are inboard of the engine nacelles and two outboard. The arrangement of engines is particularly interesting, since double engines are employed. Those in the original model were DB606 motors, arranged side by side, but the present version has two DB610 engines, each of which is composed of two DB605 power units coupled together. The engines are buried in the wings, and each double-engine unit drives a four-bladed airscrew. The frontal radiators are mounted in the wing and provision is made for diving brakes, which are attached outboard of the engine nacelles. The output of this new type of bomber, which has been under development since the early years of the war, has, it is believed, been delayed considerably owing to the great need of the enemy to concentrate his production on fighters for defensive purposes.

F.B.I. President's New Year Message

SIR GEORGE NELSON, President of the Federation of British Industries, in a New Year message, says: "If 1943 was the year of promise, 1944 may well prove to be the year of fulfilment. Industry, glancing back along the road, realises what has been accomplished in the field of production by good will, co-operation, and common purpose. Now for the last lap of the war! And then ahead of us lie the problems and opportunities of building for peace, which can be made secure by maintaining the spirit of unity that has guided us in war. Industry is proud of the men and women who have carried on so steadfastly in the workshops of Britain. One day it will be possible to tell the story more fully. Meanwhile, we shall keep at our task of helping to provide the people at home with the necessities of life and the gallant men of the United Nations with the equipment for victory."

The Peacetime Service of Railways

AT the "coming of age" luncheon of the four amalgamated railways, which took place at the Dorchester Hotel and was briefly referred to in our last issue, messages were received from the King and the Prime Minister. Sir Ronald Matthews, the chairman of the L.N.E.R. and the Railway Companies' Association, presided and proposed the toast of "Lord Leathers, the Minister of War Transport." He said that the aim of the railways in peacetime was to give the finest service to the travelling public and to industry; to provide regular employment at a fair level of wages and under the best possible conditions; and to pay a reasonable dividend on the capital invested. Such a programme, Sir Ronald said, was perfectly possible if steps were taken to bring about a proper balance between the different forms of transport, particularly in their several responsibilities to the public, their charging powers, their rates of wages and hours of labour. Too much irresponsible and often cut-throat competition, such as we experienced before the war, did no good to the transport industry as a whole, and, by making it impossible to earn sufficient revenue for re-equipment, in the end could only result in a steadily deteriorating service to the public. On the other hand, too much planning, too much co-ordination and centralisation, might have an equally stultifying effect, and in the long run produce a condition of unenterprise, about which we had heard so much recently. Those who would have the responsibility of directing the railways after the war were confident that if the British gifts of common sense, practical wisdom, and fair play were applied to rail, road, sea, water, and air, the transport industry of this country, under the stimulating urge of private enterprise and competition by service, would succeed in forging for the nation an even stronger weapon than ever before.

Engineers and the British Empire

By Professor MIDDLETON SMITH, M.Sc., M.I. Mech. E., LL.D.

No. XXVI—(*Continued from page 499, December 24th*)

The West Indies

THE West Indian islands have not made the economic and social progress that might have been hoped from a century of freedom. Sugar has been "king" even in decline, although other crops have been fairly successful. It would appear that the West Indies, with their army of unemployed labourers, who have neither land nor agricultural tradition, and many living in abject poverty, need extensive public works, such as draining and reclamation, not only as relief measures, but as necessary improvements. Some of the small Colonies are very poor. Much hope is centred on the Colonial Development Fund, which means, of course, payment by the British taxpayer. The products of the many islands are derived almost entirely from vegetation.

Great Britain governs an area of about 12,000 square miles, out of an island total of 100,000 square miles. The largest of our island Colonies is Jamaica. The coast is indented with good harbours, of which Port Royal, the port of Kingston, is the most important. Kingston is a modernised city with nearly 900,000 inhabitants. On the island, in addition to many plantations, there are cigar factories, tanneries, ironfoundries, electric light and gasworks, and factories to produce cocoa-nut oil, &c. The islands are scattered—Jamaica is 1000 miles distant from Barbados or Trinidad—the latter being interesting because of the pitch lake which contains millions of tons of asphalt. There are also extensive and valuable oil-fields, yielding annually nearly 100 million gallons of crude oil, which is conveyed through pipes to ships.

On the mainland are the Crown Colonies of British Honduras and British Guiana, the latter containing great potential water power, timber, and much bauxite. With engineering developments—transport, drainage, &c.—it could accommodate at least fifty times as many inhabitants and yield up much potential wealth, but the present small population—about 300,000—for a huge area, which includes 78,000 square miles of forest, with mountains up to and over 8000ft., makes transport expensive for probable returns.

Progress in Ceylon

Prior to the British occupation of the island of Ceylon in 1815 there had been no adequate means of transport under Dutch rulers. The rapid provision of roads and bridges in the mountainous tropical areas was not an easy or pleasant task for the British pioneer engineers, but planters and merchants profited by the highways. Then came the building of the Ceylon Railway, which was described by a prominent native as "the greatest of the many material advantages which accrued to the island by reason of its contact with the Englishman."

In 1831 there were carriage roads connecting every town of importance. Major Skinner built the Colombo and Kandy road to a height of 1654ft. The first mail coach service in Asia ran over it daily in 1832, taking fourteen hours up and twelve down. The railway joining the two towns was built in 1867. The pioneers had to overcome strong opposition, due to prejudice and difficulties presented by the natives. In 1896 there were 297 miles of excellent railway; in 1925 the length was 747 miles. In 1940 the road mileage suitable for motors was 5633; one climbs up to Nurwara Eliya, 6240ft. high.

There are many tunnels and bridges, embankments, and laborious twists. "No railway in the East," writes an engineer, "has reached the altitude [over 6000ft.] attained by the Ceylon Railway in so short a distance, on a gauge so broad [5½ft.] and with gradients so steep and sharp." On one incline the gradient is 1 in 45; 10-chain curves were used to raise the line 1385ft., an average of 106½ft. per mile.

The harbour in Colombo is well protected by breakwaters; passengers from liners go ashore in boats. A great deal of shipping uses the harbour.

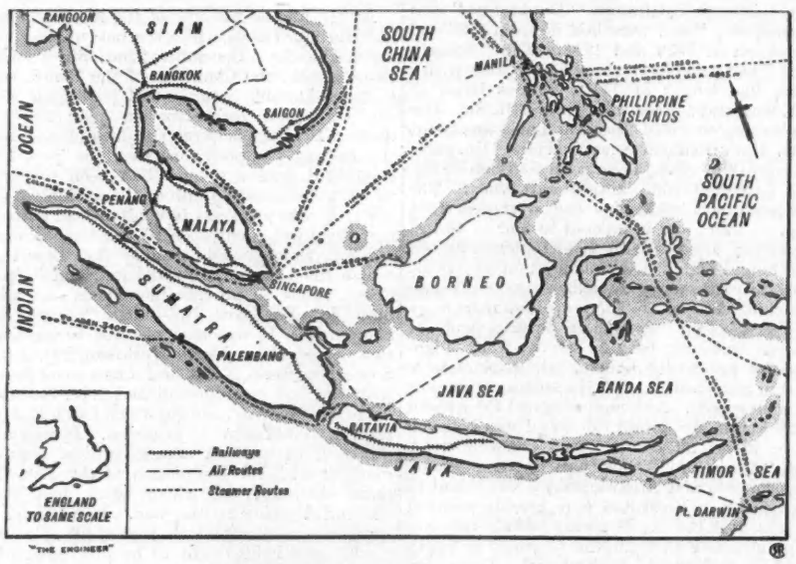
A big and attractive hydro-electric scheme, but for political vagaries, would have been completed years ago. The London consulting engineers finally recommended a scheme, the first stage of which is in hand and will provide 12,000 kW. When stages 2 and 3 are completed 100,000 kW will be available.

A prominent official in Ceylon has stated that "the whole of the water power economically available in this country is over 1 million H.P. and is barely sufficient to meet the needs of our 6 million inhabitants for their social, economical, and industrial development."

Far Eastern Colonies

The most flourishing portion of the Colonial Empire during the first four decades of this century was Malaya. Its exports were of more value than the total of all the other parts. The British transformed a land that had been almost entirely jungle into a great centre of the tin and rubber industries, and the revenue obtained enabled extensive Public Works Department works to be carried out. The unfortunate fate of many residents caused certain critics to make many inaccurate and unjust statements about the British in Malaya. For months it was my good fortune to travel through the peninsula and to mix with Government officials, engineers, and planters—on the whole, a hard-working community in a most enervating tropical climate. Mechanical transport was extensive. On the railways air-conditioned carriages were available. In 1939 life was very different for the planters and other residents in Malaya from that which was experienced fifty years ago. The formerly isolated planters or traders, who penetrated up country, had then none of the amenities of life, such as electric supply, mechanised transport, refrigeration, and even air-conditioning, which are now in general use. As roads were built, villages sprang up, cultivation was extended, the Chinese, as everywhere else in Malaya, being pioneers.

The Government engineers carried out the work of road construction, bridges, &c., with the difficulties common to tropical areas; there was a special Drainage and Irrigation Department, which not only made possible a large increase in the production of rice, but greatly reduced the loss of human energy and health caused by tropical diseases. Rice growing usually involves irrigation, for the plants require to be submerged with running water. In 1940 the world shipments of rubber were in the region of 1½ million tons, of which 60 per cent. came from British-owned plantations. Malaya and the Dutch East Indies supplied 83 per cent. of the world's plantation rubber.



MALAYA, THE EAST INDIES AND THE PHILIPPINES

The Chinese were very active in Malaya as traders, also as owners of rubber plantations and tin mines, while many were employed as coolies. Most of the wealth of the country was owned by Chinese, many of whom had commenced life as coolies. A large number of Tamils from India were employed on rubber plantations, and the Government engineers had to supervise the work of many Chinese and Tamil coolies. There were more Chinese in Malaya than Malays, but the British Government always considered the interests of the Malays before those of other races.

The two great centres of commerce were the ports of Singapore and Penang. The amazing development of Singapore, in about 120 years, can be regarded as a monument of British enterprise and justice. Stamford Raffles purchased a small island, about the size of the Isle of Wight, on behalf of the East India Company, from the Sultan of Johore. There were only a few huts on the island. One of the most important ports in

the world and a great centre of commerce gradually evolved. In 1939 there was a city of over 600,000 residents, mostly Chinese, on the south side of the island. The port had been developed with all modern equipment for dealing with cargo. Millions had been spent on a great naval base. It was not until about seventy years ago that British influence extended into the Malay States.

It is not possible to describe many of the engineering works, but one of the facts that impressed itself upon me was that, although Chinese coolie labour is the cheapest hand labour available, yet in recent years the real value of mechanism—as, for example, mechanical excavators—became fully appreciated in Malaya.

WATER SUPPLY OF SINGAPORE

The first water supply of Singapore was drawn from sources from within the island.

MALAY STATES

In 1919 the municipal engineering staff began to investigate and survey possible sources, both on the island and on the mainland in Johore for future supplies. As a result of these preliminary reports, Messrs. Binnie, Deacon and Gourley, consultants of Westminster, were asked to recommend extensions. Later, they were appointed to design and carry out new works. The sources on the island supplied 12 million gallons per day, which was about the consumption in 1921, when the population was 426,000. In 1930 the consumption had risen to 17 million gallons per day.

Two large reservoirs, some distance apart, were formed in Johore valleys by building dams. There was dense tropical jungle; large areas were denuded of trees and drained; men were employed on daily tours of inspection of drains and to spray with oil any damp ground or places where there was standing water. Even large granite boulders, weighing 700 tons, had channels cut in the rock to drain the water away. One side of the valley was transformed into a village for 1200 people, with adequate supplies of water, sewerage, and electricity.

The first reservoir created has a drainage area of 1550 acres, contained 1220 million gallons, and supplied Singapore by gravity with 6½ million gallons a day. The pipe line from the dam to the service reservoir was designed to carry 12 million gallons a day, so as to include water from other sources. As the famous causeway had been constructed, the pipe line was laid in the road across the straits and through a subway under the lock.

The creation of the second reservoir involved clearing the jungle, anti-malarial measures, and the construction of buildings, and an access road, 8400ft. long, through dense jungle and over swampy ground. The reservoir contains 2200 million gallons, and has a drainage area yielding 9 million gallons a day to Singapore. A concrete cut-off wall was carried down into the solid rock to a depth of 45ft. below the bed of the river. As the water level of this reservoir was low, the pumping station was constructed to house eventually eight pumps, each capable of dealing with 3 million gallons in twenty-four hours, and driven by gas engines, each of 300 H.P. The water was pumped through 3½ miles of 30in. diameter steel pipes to discharge into the clear water tank, provided by the first instalment, so that the waters of both reservoirs are conveyed by gravity through the same pipe line to Singapore.

The Singapore Harbour Board controls all public wharves, dry docks, &c. As the Suez Canal takes vessels of 31ft. draught, that figure indicates the requirements of Eastern ports for depth of water. There are five dry docks; the largest is the King's Dock with extreme length at bottom of 879ft., width at entrance 100ft., and depth at high water spring tides 34ft. Among other works was the construction of a large wet dock, where formerly there was an evil-smelling swamp. Merchant ships of tonnage about 15 millions per annum entered the port. The Harbour Board has its own electric power station and well-equipped workshops.

Some years ago the Japanese laid plans to cut a canal through the Kra Peninsula, just north of the Malaya boundary and in Siam. They are said to be at work on a scheme that would cut off 600 miles of the voyage from the Far East to Europe, and by-pass Singapore. It is said to be a more difficult task than the Panama Canal, and is unlikely to be completed, if it has been commenced.

Electricity was in increasing demand all over the peninsula. In Singapore the municipal authorities sold 128,188 units in 1907 and nearly 27 million twenty-five years later. Costs per unit fell from 50 cents (1s. 1d.) to about 6½ cents in that period, evidence of the increase in efficiency of production.

The construction of railways caused few difficulties other than those usual in the tropics. The main problem was bridges. The longest, over the Perak River, is seven spans of 150ft., and on the east coast over the Semantan River, four spans of 150ft. The lines are metre gauge; early rails weighed 4½ lb. per yard, but on more recent lines 60 lb. and 80 lb. rails were used. Excellent local hardwoods, impervious to white ants, are used as sleepers, being replaced after about ten years. As roads were built, cultivation was extended. Penang, Kuala Lumpur, Ipoh, and other towns had excellent engineering services. Motoring in Malaya over hundreds of miles of surfaced roads was a delight.

In the Malayan archipelago is Sarawak, famous for its oilfields and the romantic careers of British Rajahs. Adjoining the territory is British North Borneo, from which hardwoods, &c., were exported. These territories, like other British-governed islands in the Pacific, have had very little engineering development, but offer great opportunities for such work. In New Guinea British territory covers over 280,000 square miles. The most spectacular development was in the Wau goldfield; in 1927 the first aeroplane, carrying 600 lb. of cargo, arrived there, doing a journey in two hours which had previously taken 250 carriers, for the same load, six weeks. In 1931, in one month, 581 tons was carried to the field by aeroplane. In 1936 no less than thirty-nine aeroplanes were at work there. There are enormous water power resources in the island. There will be a tremendous development of the forest timbers, minerals, and cultivated vegetation in these thinly populated East Indian islands. It will be possible when the urgently needed interior transport facilities become available.

HONG KONG

The tragedy which has befallen the inhabitants of Hong Kong will soon become a memory, and once again British and Chinese enterprise and engineering skill will be evident and ensure progress. In almost exactly 100 years, since China ceded it to Britain, in 1841, the little island was transformed. Formerly the home of about 5000 Chinese, mostly engaged in piracy, it contained about 600,000 people when I left in 1939. It has one of the most beautiful harbours in the world; shipping was often described as "the life-blood of the Colony." Local industries, however, had been developed. Not only were ships up to 12,000 tons built in the splendidly equipped dockyards, but there were many small factories which, collectively, demanded a considerable supply of electric power. As some indication of development, the total revenue of the Colony increased in the years 1887 to 1938 from 2½ million to 36¾ million dollars, and during that half century rather more than one-fourth of the annual revenue was, on the average, spent by the Public Works Department.

The Colony in 1940 consisted not only of the island, but a small portion of land on the mainland at Kowloon, ceded about eighty years ago, a mile distant across the harbour from the City of Victoria on the island. In 1898 some 300 square miles of mainland territory behind Kowloon was granted by China on a ninety-nine years' lease. The amazing development of the town of Kowloon after 1910 was largely due to the work done by the engineers of the Public Works Department. Hills were removed and thrown into the sea; the land reclaimed and levelled was soon covered with build-

ings, including many small mechanised factories owned by Chinese. When first I reached Hong Kong in 1912 there were about 30,000 people in Kowloon; in 1937, before the Japanese invasion of South China, there were more than 300,000 people there; when the refugees streamed in the population increased to at least half a million, and that on the island—about 450,000 in 1937—exceeded 600,000.

The two Chinese words "Hong Kong" mean "sweet waters." In the early days the supply of water for ships and the harbour were the attractions that made the British decide to accept the Chinese offer of cession. As the Colony developed, an adequate supply of water was an expensive and difficult engineering problem, the solution of which was, unfortunately, delayed by the Administration, involving great hardships on local residents.

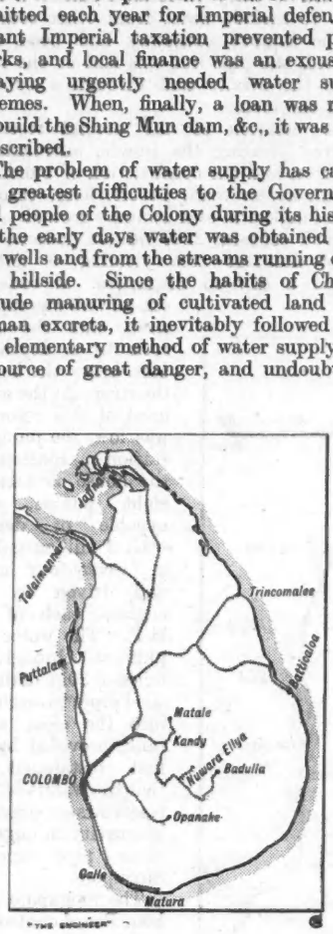
Situated at one of the delta mouths of the river that flows past the great mercantile City of Canton—100 miles up river from the sea—Hong Kong soon became the distributing centre for cargo from Europe and America for many parts of the Far East. Wharves and storehouses were built; to reduce malaria, &c., swamps were drained; hillside streams trained to flow down direct to the sea in nullahs—open drains—built of the local granite; roads were constructed; huge areas of the island reclaimed from the sea; millions of trees were planted on the hillsides, and the City of Victoria gradually expanded in size and importance.

In the early days the European residents, being within the tropics, suffered from malaria and enteric diseases. In 1844, between May and October, 24 per cent. of the British troops died. But there was no suggestion of defeatism—the British went on to effect improvements and to expand their trade. The arrival of the first small steamer in "the hungry forties" must have cheered the fever-striken inhabitants of the Colony; the coming of steam to Hong Kong was to affect profoundly, first of all the Colony, then other parts of the Far East, and finally world politics. China was given the opportunity to introduce the modern engineering works in evidence in Hong Kong. British engineers laid plans for railways, mining developments, and other schemes before Chinese officials, who, steeped in the ancient Confucian classics, foolishly despised the new knowledge and appliances offered by the British. But a certain Sun Yat Sen learned about modern science from British teachers in Hong Kong, and during his years of residence there he saw the contrast between the Colony and China, due to the enterprise, scientific knowlege, and law and order introduced by the British. He set to work to rouse his own countrymen, but he was too late to avert the tragedy that has come to China.

Some words written by the economist Dr. L. C. A. Knowles often came to my mind as I inspected in Hong Kong and Malaya the work done by the overworked Public Works Department engineers: "Many volumes have appeared about the military records of the Empire, but very little about the struggle with the overwhelming forces of Nature which took shape in the unromantic guise of public works. The struggle between the engineer and the stupendous obstacles arrayed against him have altered all Colonial values."

An expansive and comprehensive scheme for port development was drawn up about twenty years ago by Sir Maurice Fitzmaurice. Typhoon shelters have been built to shield small craft against wind velocities which have exceeded 170 m.p.h. A very extensive motor road system, for which the engineers had to negotiate very steep granite hillsides, was extended in the last two decades. The only Governor who was an engineer, Sir Mathew Nathan, initiated the railway to Canton and the splendid wide road in Kowloon more than thirty years ago. Until about ten years ago the official attitude was that all public works must be paid for out of revenue. As 25 per cent. of the revenue was remitted each year for Imperial defence, it meant Imperial taxation prevented public works, and local finance was an excuse for delaying urgently needed water supply schemes. When, finally, a loan was raised to build the Shing Mun dam, &c., it was oversubscribed.

The problem of water supply has caused the greatest difficulties to the Government and people of the Colony during its history. In the early days water was obtained from the wells and from the streams running down the hillside. Since the habits of Chinese include manuring of cultivated land with human excreta, it inevitably followed that the elementary method of water supply was a source of great danger, and undoubtedly



CEYLON

caused many fatalities during the early days. With the exception of the comparatively level areas on which parts of the towns of Victoria and Kowloon are situated, the Colony is mountainous, the highest peak on the island being 1760ft. and on the mainland about 3000ft. The capacity of any reservoir is small as compared with the height of the dams required to form it. The first effort to secure a water supply was made by building a reservoir at the south end of the island. A conduit carried this water for about 2 miles to filter beds and a service reservoir near to the City of Victoria. A few years after the occupation by the British, expert consultants from England visited the Colony in order to advise upon the best methods of securing an adequate water supply. This led to the creation of reservoirs and catchment areas, &c., in the extreme end of the island near the Lymoon Pass. A tunnel was cut through the hill between this area and the City of Victoria, and a long conduit was built to carry the water to filter beds and service reservoirs. The large Tytam Tuk reservoir was opened in 1916 by the Governor, who then stated that the new storage would suffice for many years, but he was too optimistic, for in a comparatively short time there was again a water famine, during which many thousands of Chinese had to stand in queues in order to fill their buckets at stated times from standpipes on the roadside. I was deeply impressed by the able manner in which the Public Works Department engineer, Mr. Jaffe, carried out the difficult work of designing and constructing the big dam for the Tytam Tuk reservoir. When Tytam Tuk was completed and other reservoirs had subsequently been built on the south side of the island, the gross capacity of all of them was 2360 million gallons, and there were four in the mainland having a gross capacity of 687 million gallons. Then, in 1937, a new reservoir for 3000 million gallons was completed by building the Shing Mun dam. In the years between 1921 and 1937 there were only seven when an unrestricted supply of water could be given throughout the year, and in some years the shortage was acute, so much so that water was brought by ships and placed in hastily constructed brick tanks on the quay side. This shortage was not due to the Public Works Department engineers, who had constantly warned the Government of the need for extensions. Mr. R. M. Henderson, first as Chief of the Water Department and then as a Director of the Public Works Department, made an exhaustive study of all possibilities, and finally came to the conclusion that the best solution would be to construct a reservoir or reservoirs, impounding the waters of the Shing Mun River on the leased territory on the mainland, a scheme approved by London consultants and, with certain amendments, carried out. Pipe lines were laid across the harbour and the island at last obtained a full supply.

The Hub of the Wheel of Progress

During my endeavour to collect information for this series, several Government Departments and many individuals have given me great assistance, which often involved them in a considerable amount of work in searching old records. It surprised me to discover what a vast amount of work has been done in London in connection with the development of the natural resources of our scattered Empire. From that centre many designs and ideas have gone out to aid engineers working under the most varied conditions of physical environment and human relations, with the result that the daily lives of many millions of British subjects overseas have been entirely changed. A prominent consulting engineer wrote to me to explain that he was "delighted to read that one point you wish especially to emphasise is the part played by British engineers as Empire builders. It is an aspect of the work of engineers that I have always stressed, and am still astonished at the very large number of people who do not realise that without the services of engineers in supplying communications and all the amenities of life, from water supply to ventilation, there would not have been the vast developments which have promoted trade, and, in turn, helped to create a living Empire. This is quite apart from the personal contacts they make, which the Foreign Office certainly recognises and have told me so."

A weakness of our Colonial administration has been due to the narrow academic training of those responsible for it. They have had almost certainly something of a bias against engineering, commerce, and industry. Their incorruptibility is universally admired, but the development of the natural resources in the Colonies is the foundation for raising the standard of living. All Government officials should be interested as much in economic development as in moral values, for abject poverty creates temptations. In recent years those selected for Colonial administration pursue a post-graduate course at Oxford

or Cambridge, but the only engineering subject included is surveying. It is difficult to understand why Government engineers are not given a post-graduate course, and why their pay and prospects are so inferior to the administrators. It was encouraging to read recently the spirited plea made on their behalf by a prominent consultant, Mr. W. T. Halcrow, who has been responsible for large engineering works abroad. It is hoped that other leaders in the profession will do their utmost to remedy a great injustice which must retard progress in the Colonies.

In the creation of the Empire Britain has achieved a unique success. We can answer critics by the record of the engineers. The British are trustees for the 63 million people in the Colonial Empire who are becoming aware of many new ideas. We have made mistakes — usually unwilling to take financial risks - in guaranteeing loans for engineering developments; often providing education that was not practical, tending to make natives despise using their hands. But with all our faults we have done better than any other nation, and we have had bigger problems than any others to solve.

Conclusion

We cannot leave this subject of the British Empire without a reference to the most baffling feature of the world as it exists to-day. British engineers must lift up their thoughts from the drawing board, from work in the factory, the workshop, and from construction schemes outdoors, to consider their duty as citizens of the world. While engineering science is making more rapid progress than ever to produce abundance of the necessities and even of the luxuries of life, there is a disturbing feature of our existence, for political and moral issues in recent years have been either in a state of deadlock or retrogression in other lands.

We, in the British Empire, and men in other really civilised countries, regard "power" as the power to control and utilise the forces and products of Nature for the benefit of humanity. For our enemies the word "power" means the power of man over man. They have replaced the laws of supply and demand by the gangster rules of smash and grab. In the new age of technological production, the age of abundance and human interdependence, those atavistic isolationists have formulated old theories and have attempted to fetter humanity with ancient and long-discarded tribal ideas, about Thor and Valhalla and the gaining of loot by preying on neighbours.

Engineers in the British Empire have been inspired in their various activities by the knowledge that technology has made possible the end of drudgery, poverty, isolation, and fear. They believed that the English-speaking peoples have led the world along paths of progress, which have made possible, for all humanity, the permanent establishment of the Four Freedoms of the Atlantic Charter. They have paid the price in blood, sweat, disease, and mental energy, but they thought it well worth while.

And so, as we close our rapid survey of engineering achievements in the British Empire overseas, and glimpse into the world of new generations, we engineers who have helped, in however meagre a fashion individually, to shape this new world can be satisfied that our work was not in vain, and feel pride in our profession.

The claims put forward on humanitarian grounds by Lord Lugard, in respect of tropical Africa, are unquestionably justified also for other parts of the British Empire. "We have," he writes, "added to the prosperity and wealth of these lands and checked famine and disease. We have put an end to the awful misery of the slave trade and inter-tribal war, to human sacrifice, and the ordeals of the witch doctor." The tremendous task that must be accomplished as quickly as possible, when peace returns, is the utilisation of the vast natural resources of our Colonial Empire for the benefit of humanity. In that work the engineer will play a very prominent part.

Southern "Pacifics" at Work

By W. A. TUPLIN, D.Sc., M.I. Mech. E.

No. II—(*Continued from page 507, December 24th*)

Observations on Performance

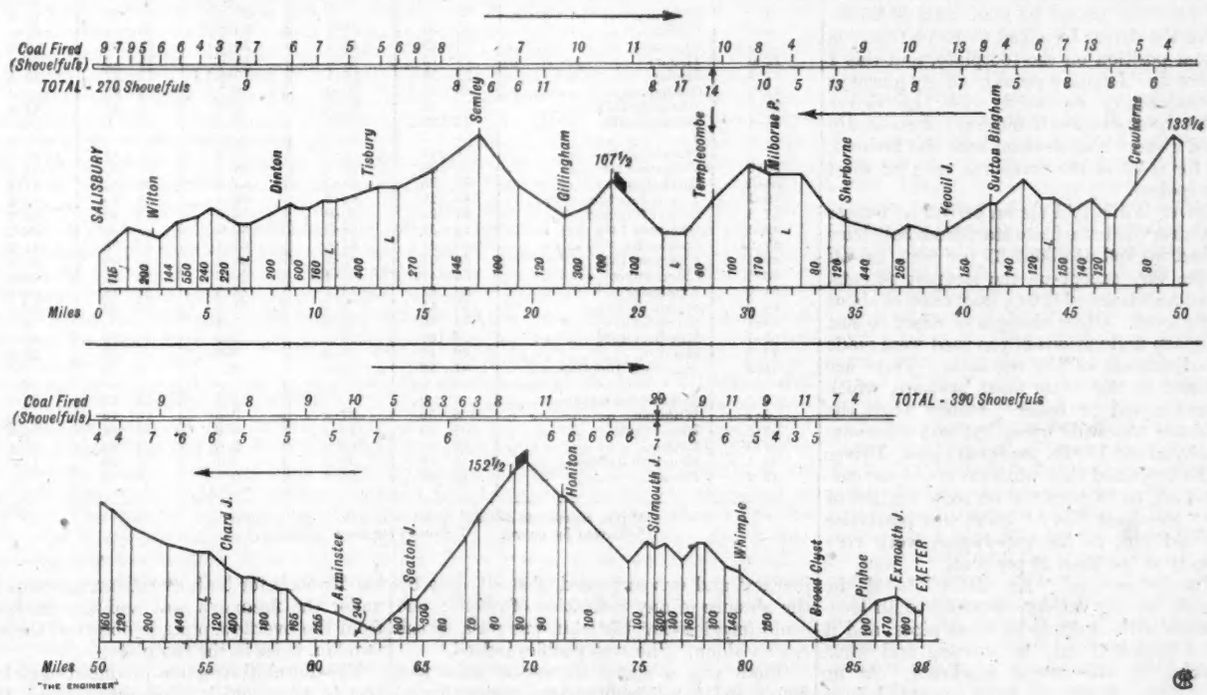
BY the kindness of Mr. C. Grasemann, Public Relations Officer of the Southern Railway, I was enabled to make footplate journeys on "Merchant Navy" class engines, and it is a pleasure to pay a tribute to the very great courtesy extended to me by every railway man I met in the course of my travels.

On each journey I recorded the times at which most stations and other important points were passed, and I also noted passing times at mileposts in order to afford some idea of the maximum and minimum speeds attained. Such observations can, however, be made by anyone in the train, and so my attention was more particularly directed to happenings on the footplate. I do not claim (as has been claimed) that it is always possible to obtain reliable figures for maxima and minima whilst primarily doing other work.

10.50 A.M. Waterloo to Exeter

On run A (Table I) I recorded only passing times, as I was in the train with Locomotive Inspector Knight (of Nine Elms), and it was far more interesting and valuable to listen to his remarks on the driving and firing of locomotives than to concentrate on stop-watch work. On this occasion Lord Monkswell and Mr. Bulleid were on the footplate, and this may have inspired the driver to exceptional efforts, but even so, it was excellent work to run the 22·3 miles from Brookwood up to Worting Junction in 22 min. 38 sec. at an average of 59 m.p.h. with 550 tons behind the tender.

At Salisbury "No. 21C9" was replaced by



PROFILE—SALISBURY TO EXETER

"No. 21C5," of the same class, in charge of Driver Willis and Fireman Padwick, of Salisbury shed, and the load was reduced to fourteen vehicles, or about 480 tons loaded. Then commenced run B (Table II), recorded from the footplate, and this was the most impressive of the journeys I made.

TABLE I

	Run	A (down)		D (up)		
	Engine	"21C9"		"21C10"		
	Load—Vehicles	16		13		
	Tons (loaded)	550		450		
Miles.		M. s.	M.p.h.	Miles.	M. s.	M.p.h.
0	Waterloo	0 0	—			
1·3	Vauxhall	3 58	19·7			
3·9	Clapham Junction	7 56	39·4			
7·3	Wimbledon	12 38	43·4			
12·0	Surbiton	17 51	54·0			
19·1	Weybridge	24 37	63·9			
21·7	Byfleet	27 06	62·7			
24·4	Woking	30 41	45·2			
0·0	Woking	0 0	—	42·0	45 35	52·8
3·6	Brookwood	7 40	28·1	38·4	41 30	61·3
8·8	Farnborough	14 08	48·3	33·2	36 25	64·2
15·4	Winchfield	20 25	63·0	26·6	30 15	65·5
23·4	Basingstoke	27 40	66·3	18·6	22 55	69·3
25·9	Worting Junction	30 18	57·0	16·1	20 45	65·1
28·0	Oakley	32 45	51·3	14·0	18 49	64·0
31·2	Overton	—	—	10·8	15 49	57·6
36·7	Hurstbourne	41 00	63·3	5·3	10 05	31·6
42·0	Andover	45 25	71·9	0	0 0	—
	Andover	(pass)	—	17·4	25 55	56·8
48·4	Grateley	52 20	55·5	11·0	19 10	40·4
53·9	Porton	60 20*	41·3	5·5	11 0†	37·7
58·3	Tunnel Junction	66 05	45·9	1·1	4 0	16·5
59·4	Salisbury	69 18	15·6	0	0 0	—

M.p.h. represents average speed from preceding timing point.
* Signal delay. † Slowed for track repairing.

Although the times represent a gain of 10 min. on the booked allowance, they have been beaten on at least one occasion by a rather less heavily loaded "King Arthur" class 4–6–0 at the very top of her peacetime form, but she must have been worked very hard to do it, whereas "No. 21C5" was merely playing with her train. On the footplate the unhurried calm of the crew and the engine's effortless running completely deceived me as to the quality of the work she was doing, and it was not until I came to examine my figures, two days after the run, that I realised what mastery she had held over load, road, and schedule.

Cut-off figures were not recorded because the indicator cannot be read with certainty unless the driver be asked to move from his normal position on the footplate, and this I did not do. I made a point in all my journeys of exchanging no word with the driver whilst the engine was in motion; occasionally I had a short conversation with the fireman, but for most of the travelling time no word was spoken.

Driver Willis told me on arrival at Exeter that after the immediate start from Salisbury he had worked at about 25 per cent. cut-off all the way except on the steepest ascents, where he advanced it to a maximum of about 40 per cent. Other changes of effort to suit the sharp undulations of the road were made by adjustment of the regulator. These are reflected in the steam chest pressure, which approximated to boiler pressure when the regulator was wide open, but was otherwise usually about 180 lb. per square inch. Driver Willis explained that while he would use cut-offs down to 18 per cent. on some engines of the "Merchant Navy" class, this particular one did not, in his experience, work very happily at less than 25 per cent.

The exhaust of "No. 21C5" is of the sharply hissing variety, common to all locomotives with multiple-jet blast pipes, and it could be heard only on starting and when working up the steeper gradients. At no other time would one have suspected from sensations on the footplate that the engine contained any reciprocating parts at all.

Whilst "No. 21C5" was going, the cab was filled with the deep rumble inevitable in the running of a steel-wheeled vehicle over steel rails, and this increased with rise in speed, but was not excessive even at the highest speeds. I have travelled in motor buses that were as noisy as this engine, but in none that moved so comfortably, for "No. 21C5" rode with remarkable steadiness under all conditions and there was never the slightest suspicion of roll or sway at any point on the route. The exceptionally smooth riding was perhaps the most impressive feature of the journey, and was surpassed, if at all, only by the absence of any indication of effort; one could imagine that the train was pushing the engine along. She was pacific, indeed.

There was a sharp shower of rain just before we left Salisbury and the engine slipped once on the wet rails, but after that the weather was warm and sunny with little wind, and Driver Willis had nothing to worry him. From his position at the left-hand side of the cab he watched the line ahead and the beautiful country through which we were passing, only rarely sparing an inward glance, and even that was perfunctory, for nothing of importance escaped the attention of Fireman Padwick. His spells of firing averaged about eight heaping shovelfuls each and were carried out with sufficient deliberation to permit him to discard occasional bits of near-coal that would have done "No. 21C5's" digestion more harm than good.

The coal was Welsh, with a certain amount of slack, and most of it was placed in the rear quarter of the length of the grate, where the top surface of the fire was kept "black" and at a rather higher level than the bottom of the fire-hole. Apparently the fire-box vibrates more severely than does the footplate, for although the crew and their visitor felt no discomfort, the burning coal was shaking about continuously at all speeds above about 30 m.p.h., and thus remained admirably loose, evenly spread and free from holes. As the grate slopes downwards to the front, the fire tends to work forward and the fireman's main care is to keep the rear end supplied. "No. 21C5" had the reputation of being a shy steamer, but on this journey the boiler pressure was maintained with no apparent difficulty at 240 lb. to 260 lb. per square inch.

Between spells with the shovel, Fireman Padwick swept the footplate clear of small coal, glanced at steam and water gauges, stopped or started injectors, and once shouted a reassurance to the driver about the indication of a signal that could be seen sooner from the right of the cab than from the left. Although not overworked, he was never idle for a moment and never made use of his tip-up seat. Steam and water control hand wheels for both live steam injectors are under the fireman's seat and the discharge from the overflow pipes is observed through two 2in. holes in the footplate.

The downhill stretches produced some high speeds after quick acceleration, and they were evidenced by stop-watch readings,

TABLE II

	Run	B (down)		C (up)		
	Engine	"21C5"		"21C5"		
	Load—Vehicles	14		13		
	Tons (loaded)	480		450		
Miles.		M. s.	M.p.h.	Miles.	M. s.	M.p.h.
0	Salisbury	0 0	—	28·4	31 31	43·1
2·5	Wilton	6 30	23·1	25·9	28 02*	68·0
8·2	Dinton	13 43	47·4	20·2	23 00	68·0
12·5	Tisbury	18 12	57·5	15·9	19 12	58·2
17·6	Semley	23 28	58·1	10·8	13 57	50·5
21·7	Gillingham	26 59	70·0	6·7	9 05	46·4
23·7	Mile-post 107¼	28 50	64·8	4·7	6 30	43·4
28·4	Templecombe	32 28	77·7	0	0 0	—
	Templecombe	Pass	—	47·4	61 42	35·2
30·8	Milborne Port	35 08	53·0	45·0	57 36	38·5
34·5	Sherborne	38 23	68·3	41·3	51 50	57·1
39·1	Yeovil Junction	42 22	69·3	36·7	47 00	32·4
41·3	Sutton Bingham	44 24	65·0	34·5	42 55†	39·3
42·5	Mile-post 126¼	45 54	48·0	33·3	41 05	68·2
47·9	Crewkerne	50 41	67·8	27·9	36 20	43·6
49·5	Mile-post 133¼	53 02	40·7	26·3	34 08	49·4
55·9	Chard Junction	58 47	66·7	19·9	26 21	60·0
61·0	Axminster	62 53	74·7	14·8	21 15	60·9
64·3	Seaton Junction	65 41	70·7	11·5	18 03	53·2
68·7	Mile-post 152¼	72 30	38·7	7·1	—	—
69·7	Mile-post 153¼	74 45	26·7	6·1	11 58	32·5
71·2	Honiton	76 43	45·8	4·6	9 12	30·0
75·8	Sidmouth Junction	81 22	59·4	0	0 0	—
0	Sidmouth Junction	0 0	—	12·2	22 18	31·6
3·7	Whimple	5 56	37·4	8·5	15 16	49·0
7·4	Broad Clyst	9 00	72·3	4·8	10 44	56·5
9·3	Pinhoe	10 47	63·9	2·8	8 43	29·0
11·1	Exmouth Junction	12 49	53·1	1·1	5 00	13·2
12·2	Exeter	15 28	24·9	0	0 0	—

M.p.h. represents average speed from preceding timing point.
* Slowed for curve. † Slowed for track repairing.

increase in gale force as one leaned outside the cab to "catch" the mile-posts, and increase in cab noise, but never by any change in the riding of the engine, for that was perfect throughout.

After climbing past Crewkerne to the summit at mile-post 133¼ with a minimum speed of 39 m.p.h., "No. 21C5" swept smoothly down to Axminster with steam chest pressure not higher than 120 lb. per square inch, and gave the train a useful degree of momentum at the bottom of the dip.

On the ascent past Seaton Junction to Honiton tunnel the regulator was opened wide and later still Driver Willis advanced the cut-off to 40 per cent., whereat Padwick and I exchanged mock frowns, as if to say, "That's right, thrash her, don't bother about the poor fireman." Actually there was no appreciable increase in the rate of coal consumption, and the engine, with exhaust beats now plainly audible from the cab, climbed through the deep cutting and into the tunnel without any hesitation beyond a momentary slip which corrected itself.

The walls of the tunnel reflected the sound of a slight knock in one of the big ends and the darkness enabled me to note that the graduations and needles of all the gauges bear luminous paint; there was no need to use the electric light available in the cabs of these engines. The paint used is specially prepared to enable it to react to rays projected from an ordinary electric lamp through a dark violet glass. There is therefore no reflection from the gauge glasses which would interfere with the driver's vision.

Current for the whole electric lighting system is supplied by a steam turbo-generator.

On the descent from the western mouth of Honiton tunnel speed rose rapidly, but Sidmouth Junction is situated at the top of a sharp up gradient, and so only a moderate brake application sufficed to make a smart stop with the engine on the level crossing. It was necessary to "draw-up" after a time in order to bring the rear part of the train abreast of the platform, and the nominal allowance of three minutes for the station work was considerably exceeded.

Whilst the train was standing, the fireman placed a comparatively heavy charge of coal on the fire and made further additions on the way down to Exeter. This was preparatory to banking the fire for a two-hour wait at Exeter, after which it would take the engine for a few miles on the way back to Salisbury. Otherwise on a locomotive finishing its duty at Exeter, the last addition to the fire may be made on Seaton bank.

Driver Willis ran easily over the last stage of the journey, the maximum rate at Broad Clyst being well below peacetime figures at this point, and when we drew up at Exeter Central with the platform clock indicating 2.28 p.m. he was able to say with justifiable satisfaction "Right time!"

10.35 A.M., EXETER TO WATERLOO

On the day after my journey to Exeter, I joined Driver Sharland and Fireman Roke, of Exmouth Junction running shed, on the engine allotted to the 10.35 a.m. up train from Exeter. This proved to be "No. 21C5" again, and it was specially interesting to see the same engine handled in a somewhat different manner from that adopted by the Salisbury men.

Driver Sharland said that he worked "Merchant Navy" class engines at 15 to 20 per cent. cut-off in average conditions, but that the steepest gradients of the Salisbury–Exeter route called for a maximum of about 40 per cent. He mentioned that these engines are prone to slip when starting. In this respect they are similar to many other modern locomotives, for if the cylinders are large enough to utilise the full output of the boiler with an early cut-off, adhesion weight chosen to suit normal running conditions is likely to be inadequate to prevent slipping when full boiler pressure is allowed to act on the pistons over a high proportion of their stroke.

When I reached the engine at about 9.50 a.m. she had a moderately deep fire of Welsh coal already well burned through, but Fireman Roke made no addition to it until nearly an hour later, when we had covered some 7 miles of our journey. In the interval he made use of the injector and adjusted the blower so that when we drew out of Exeter with thirteen vehicles behind the tender the boiler pressure was 245 lb. per square inch and the water level showed at the very top of the gauge glasses. Incidentally, the gauges had to be "blown down" occasionally to make then show equal readings.

Rain had been falling for some time before the start was made and the engine slipped several times on the rise to Exmouth Junction. Driver Sharland therefore took things easily at first, as with steam chest pressure ranging from 200 lb. to 220 lb. per square inch we ran at about 35 per cent. cut-off before coming down to 20 per cent. on passing Pinhoe. The regulator was partly closed for the descent to Broad Clyst and shortly after we passed that station Roke commenced to fire. His general practice was to limit each spell of firing to five or six shovelfuls—a moderate amount on a grate of nearly 50 square feet—and he thus maintained a bright shallow fire with a negligible area of "black." As on the down trip, most of the coal was placed in the rear part of the fire-box, but occasional small amounts were thrown on to the middle of the fire. Fireman Roke stopped and restarted injectors rather more frequently than did Padwick and apparently aimed at keeping the water level halfway up the gauge glasses. Over a road such as this the change from up gradient to down gradient may cause the water gauge reading to fall by 6in. in a few seconds, and so the fireman needs considerable experience if he is to handle the injectors to the best advantage.

After restarting from Sidmouth Junction, Fireman Roke contrived to raise the boiler pressure to 260 lb. per square inch, at which point "No. 21C5" commenced to "blow off," although the nominal working pressure is 280 lb. per square inch. On passing Honiton there was some slipping, checked by sanding the rails and momentarily closing the regulator. We entered the tunnel at about 26 m.p.h., and although the gradient inside it is favourable to this direction of running, "No. 21C5" slipped so persistently (with the usual accompaniment of thunderous rumbling in the cab) that the driver at last shut off steam altogether until we reached the open air again. A short spell with partly open regulator helped the acceleration over the first half mile, after which we drifted down the bank without steam. Here Driver Sharland thoughtfully examined the axle-box oil feed trimmings, which are contained in two large boxes mounted at waist height on the back plate of the boiler. Speed continued to rise and as we swept round a "blind" bend at 70 m.p.h. it was comforting to realise that as we were not on the King's highway there was no risk of finding our path blocked by vehicles racing up to meet us.

On the long rise to mile-post 133¼ the regulator was well open and cut-off maintained mostly at about 20 per cent. It was notable that in these circumstances a slight knock could be heard in a big end, and this tended to confirm Driver Willis's opinion about the reaction of "No. 21C5" to early cut-offs.

A southerly wind caught us on exposed parts of the line and drove a gale across th front of the tender. It was remarkable how frequently agricultural odours penetrated into the cab, but under grey skies after a morning of heavy rain the smell of new-mown hay was somewhat melancholy.

A long slowing for track repairs near Sutton Bingham, cost us nearly two minutes, and we had exceeded the booked allowance by about that amount when we reached Templecombe.

Contrary to his usual practice, Fireman Roke placed fourteen shovelfuls of coal on the fire whilst we stood in the station and followed this by a still heavier charge after we had got under way. Subsequent shorter spells averaging eight shovelfuls each enabled us to reach the summit at Semley with the steam gauge reading 240 lb. per square inch. After that, with 17 miles of favourable gradients to the end of the run, the fireman's work was almost finished. With steam chest pressure at about 180 lb. per square inch we reached a maximum of 70 m.p.h., but after a sharp reduction of speed for the curve at Wilton drifted gently down to Salisbury.

We had suffered a loss of about 4¼ min. between Exeter and Sidmouth Junction, but more than balanced it by a gain of 5¼ min. from Templecombe to Salisbury.

Engines were changed at Salisbury and the newcomer was another "Merchant Navy" "No. 21C10," in the charge of Driver Alexander and Fireman Pett, of Nine Elms; the load remained unchanged. The engine arrived with a moderately deep fire of Welsh coal, the water level high in the gauge glasses, and the boiler pressure at 270 lb. per square inch. Before we started, Fireman Pett loosened the rear part of the fire with the pricker and did not add coal until we had passed Tunnel Junction. His spells of firing, as measured by the number of scoops from the tender, were longer than those adopted by the other men with whom I travelled, but he took smaller amounts of coal on the shovel and plied it more rapidly. He paid special attention to the back corners of the fire-box, and his deft shots into more distant parts of the grate were a delight to watch.

Driver Alexander favoured a partly opened regulator with a comparatively late cut-off. On the rise to Grateley the boiler pressure was maintained at not less than 240 lb. per square inch, the steam chest pressure was about 160 lb. per square inch, and the exhaust could be heard thinly chattering away in the chimney. On the following down gradient there was a quick acceleration and we had topped 70 m.p.h. before the brakes were applied for the stop at Andover.

The riding of "No. 21C10" was just as good as that of "No. 21C5," and I understood from the enginemen that in this respect there is nothing to choose between any of the ten engines in the class.

From Andover to mile-post 62½ the locomotive was handled in the same way as on the rise to Porton, but was then somewhat eased, although the speed was over 60 m.p.h. as we passed Overton. At Oakley the boiler pressure had been allowed to fall to 190 lb. per square inch with the water level halfway up the glass and the steam chest pressure was 100 lb. per square inch. At Worting Junction steam was shut off and we drifted along at about 68 m.p.h. until the regulator was reopened at a point about half a mile beyond Basingstoke. Thence the engine was working easily, the speed remaining at 65 m.p.h. or so and the steam chest pressure down to as

little as 85 lb. per square inch until steam was shut off for the stop at Woking.

Here Inspector Knight joined the engine and I left it to seek washing facilities in the train, as I was compelled to hurry away from Waterloo as soon as we arrived.

COAL CONSUMPTION

On the gradient profile an indication is given of the rate of firing on the up and down journeys between Salisbury and Exeter. The difference between 390 shovelfuls on the down journey and 270 in the other direction appears at first sight to be large. It must be remembered, however, that between Honiton and Exeter the fire was being built up for the return journey; if this had not been done, no coal need have been added to the fire on the final length and the total consumption would have been about 320 shovelfuls.

In comparing 320 with 270 it has to be considered that the down journey was made at a higher average speed, and with a heavier load than the up journey, and the difference of 50 shovelfuls is about what one might expect. Any such comparison is only approximate, first, because a "shovelful" is a variable quantity, and secondly, because there can be a considerable difference between the amounts of fuel in the fire-box before and after the run with a grate area so large as 48·5 square feet.

GENERAL COMMENTS

The impression I gained from these footplate experiences is that the locomotives of the "Merchant Navy" class can very easily handle the heaviest passenger trains at present running on the Southern Railway and could observe pre-war timings with them if required. In the words of the operating staff, "They can do the work," and that, from locomotive men who do not lightly accept innovations, is lavish praise.

The power-operated fire-door is a great help in minimising the entry of air into the fire-box when the engine is working hard. Those I saw were in need of some slight adjustment, as they did not always work with absolute perfection.

The problem of obstruction of the driver's view by exhaust steam, successfully solved on earlier Southern locomotives by the fitting of vertical sheets alongside the smoke-box, has reappeared in the streamlined "Merchant Navy" class, and experiments are still being made to overcome it. A drastic solution would be to lead the exhaust into an enclosed duct extending along the top of the boiler and discharging to atmosphere behind the cab. Looking still further into the future, one may imagine a 2–6–4 locomotive normally running bogie first behind a tender designed for safe propulsion at the highest speeds and for such clear vision that all signals can be seen from the driver's side.

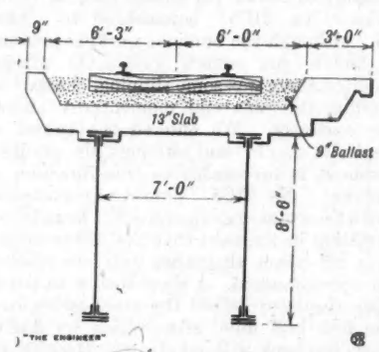
In the meantime, however, the Southern Railway may be congratulated on possessing in the "Merchant Navy" class a stud of locomotives that are equal to any task likely to be set to them for a long time ahead.

American Impact Tests on Railway Bridges

RESEARCH investigations as to the effects of impact in the stresses on railway bridges under traffic have been studied for the past few years by the Impact Committee of the American Railway Engineering Association, and a recent report of tests made by the Pennsylvania Railroad on a deck girder plate girder bridge of 81ft. span has been published by the Committee in a 1943 *Bulletin* of the Association. This report supplements previous reports on tests made by the same and other railways.

When the four-track line of the Pennsylvania Railroad between New York and Washington, 230 miles, was converted to electric traction, it was desired to study the comparative impact effects exerted on bridges by steam and electric locomotives of approximately equal weight, and operating at high speeds. Since there was little definite information as to the dynamic forces imposed by the electric locomotives, it was decided to make a series of tests on several bridges with both the electric and steam locomotives to be used on this particular line. The first tests were made on a four-track bridge with half-through girders. Following this, tests were made on a single-track plate-girder deck bridge having two spans of 56ft. and 122ft., and having a floor of the open type, in which the wood ties or sleepers are laid directly on the top flanges of the girders. The third set of tests, reviewed in the report above mentioned, was on a plate-girder bridge having a solid and ballasted floor, as shown in the accompanying drawing.

This bridge was selected in order to determine, first, the effect of the damping of the dynamic stresses due to the increased stiffness and the ballast; and secondly, the portion of the top flange stress that was carried by the concrete floor or deck. It is a single-track span of 81ft. between centres of bearings, with 8½ft. girders, 83ft. long overall, spaced 7ft. apart, and having the usual lateral bracing of cross struts and diagonals. Upon the top flanges of the girders rests a 13in. concrete slab, which was poured in place and has low side walls to retain the stone ballast, which is 9in. deep under the wood ties. The width over the side walls is 16ft., including a wall 9in. thick on one side, and a 3ft. flange on the other side to form a walk for the trackmen. The bottom of the slab embraces the



SECTION THROUGH PLATE GIRDER BRIDGE

top flanges of the girders, so that it appears the concrete floor was well bonded to the steel and that the entire section acted as a composite beam.

Locomotives of five types were used in the impact tests: (A) electric, 4–6–4, 200 tons; (B) electric, 4–6–6–4, 230 tons; (C) steam express passenger engine, 4–6–2, 157 tons; (D) similar engine of 168 tons; (E) steam freight engine, 4–8–2, 200 tons. These weights are exclusive of the tenders. The test runs were made by the engines and tenders, but with no carriages or trains attached.

Stresses and vertical deflections were measured in each girder under these five locomotives at speeds ranging from 5 m.p.h., which may be considered as static loading, to a maximum of 110 m.p.h. for the electric locomotives, 99 m.p.h. for the steam passenger locomotives, and 76 m.p.h. for the steam freight locomotive. Electro-magnetic strain gauges were used for measuring the strains. Besides comparison of the results recorded, comparison was made with the impact regulations embodied in the standard specifications of the American Railway Engineering Association for steel bridges.

In these specifications it is provided that to the maximum computed static live load stresses there shall be added the impact, consisting of the rolling effect and the direct vertical effect. The rolling effect is due to the rolling of the live load from side to side, and is taken as increasing the static live load on one rail by 20 per cent., with an equal decrease on the other rail. The direct vertical effect with steam locomotives includes the hammer blow, irregularities of track, and carriage impact. The percentage of static live load to be added for spans less than 100ft. is taken as 100 minus 0·60 of length L. For longer spans it is computed from the formula A below. With electric locomotives this vertical effect covers only track irregularities and carriage impact, and the percentage of static live load to be added is computed by the formula B.

$$\text{A}\quad \frac{1800}{L-40}+10 \qquad \text{B}\quad \frac{360}{L}+12{\cdot}5$$

In general, on this 81ft. span with solid floor there was an increase in impact effect with an increase in speed, but this increase was moderate, except for one of the steam passenger locomotives. In the accompanying table the total impact values given are averages of five of the maximum impact effects for each locomotive. For comparison with the two series of previous tests on open-floor plate-girder bridges, the impact effects found on these spans are given in the table, together with the impact values specified by the design specifications and rating rules of the American Railway Engineering Association.

In studying the magnitude of the individual effects which make up the total live load plus impact effect, it was found that the practically static stresses recorded under locomotives crossing the bridge at only 5 m.p.h. were considerably below the calculated static stresses based upon the assumption that the concrete deck was not carrying any of the stress. But assuming that this deck was acting with the steel as a composite beam, the recorded stresses were only slightly lower than the calculated stresses. The ratio of recorded stresses to calculated stresses ranged from 0·72 to 0·75 when considering the steel structure only, and from 0·88 to 0·95 when the steel and concrete are considered as acting integrally.

The recorded measurements show that vibrations were induced by the electric locomotives, even though there were no periodic disturbing forces such as are set up by unbalanced wheels. This impact effect, termed "track effect," is considered due mainly to irregularities in track surface or wheel treads, or to other conditions of track and locomotive that would tend to produce a vertical vibration in the springborne weight of the locomotive or in the girders. In the combined track and hammer-blow effect for the steam locomotives the measured values were well below the calculated values, but

the latter are based upon the damping factors in open-floor bridges, while in the solid floor ballasted bridge its increased stiffness and higher frequency gave greater damping qualities. A "speed effect," or increase in stress due to speed, was found throughout the tests, distinct from the vibrations developed by the moving loads. For this bridge it was quite as small, the maximum being from 5 to 6 per cent.

An increase in stress in the steel under one rail and a corresponding decrease under the other rail, as usually shown by the stress measurements, is the "roll effect" caused by the oscillation of the springborne weight of the locomotive about a longitudinal axis. The recorded values were well below the provisions of the design and rating rules of the American Railway Engineering Association. That the concrete floor or deck was acting as part of the upper flanges of the girders was indicated by the fact that the measured and calculated stresses in the upper flanges averaged only 30 per cent. of those in the lower flanges. From a comparison of the stresses in the upper and lower flanges it appears that the neutral axis of the section is not at the centre of the girder web, but is quite close to the upper flange. In order for the concrete deck to act as a part of the upper flange the concrete and steel must develop a bond stress of 64 lb. per square inch for the heaviest locomotive, which is not an excessive figure. In addition to this bond between concrete and steel, the rivet heads in the girders are capable of developing mechanical anchorage.

Conclusions based upon these tests and their results may be summarised as follows :— First, the poured-in-place concrete deck was well bonded to the steel and the entire section acted as a composite beam ; secondly, the recorded static stresses were only about 75 per cent. of the calculated live load stresses based upon concentrated wheel loads and the steel section only, but the recorded static live load stresses were about 91 per cent. of the calculated stresses based upon the concentrated wheel loads and taking the combined steel and concrete section, while they were about 95 per cent. of the calculated stresses when the rail was considered as acting as a continuous beam on an elastic support.

As a third conclusion, the track effect stresses for the electric locomotives, with track in normally good condition, were somewhat greater than those provided for in the rating rules of the A.R.E.A. (or American Railway Engineering Association). There was an exception to this, however, at the high speeds. Fourthly, the combined track and hammer-blow effects were appreciably lower than the hammer-blow effects provided for in the above rules. Fifthly, the increase in stress due to speed was very small in this bridge and seemed to bear no relation to speed. On the other hand, larger speed effects have been found in previous tests on other bridges. Sixthly, the stresses due to roll in this bridge were appreciably lower than those provided for in either the design specifications or the rating rules of the A.R.E.A. Seventhly, the total impact percentages based upon the recorded static live load stresses were appreciably lower than those provided for in the above specifications and rating rules.

Eighthly, basing the computations on the steel section only, it appears that the recorded maximum stresses were appreciably lower than the live load plus impact stresses as calculated by either the design specifications or rating rules of the A.R.E.A. Furthermore, the recorded maximum stresses were generally lower than the calculated static live load stresses. Ninthly, it is evident that the amount of damping in this bridge was greater than it would be in an open-deck span of equal length, and that this increase is due in part to the cushioning effect of the ballast and the higher natural frequency of the span resulting from the condition of the concrete and steel acting as a composite beam. Tenthly, it can be assumed with safety that if the bond between the concrete floor and the steel structure is sufficient to make the two parts act together, the static live load stresses will be considerably smaller than those in a similar steel span having an open deck ; also that, due to the increased damping, the amount of impact will be reduced materially.

The rating rules mentioned in the above conclusions are those for determining the rating or classification of existing bridges as based upon the heaviest moving load which may be operated over the bridge in regular service for a limited time, without subjecting it to such severe stresses, vibration, or wear of parts as to impair seriously its safety or serviceability. This carrying capacity is to be determined by the computation of stresses based on authentic records of the design, materials, workmanship, and physical condition of the bridge, including data obtained by inspection and also by tests if the records are not complete.

Impact Stresses in Railway Bridges

Locomotives.	Speed, ave.	Recorded impact. Ave.	Recorded impact. Max.	A.R.E.A. impact. Design.	A.R.E.A. impact. Rating.
Ballasted deck bridge, 81ft. span :					
Electric, 4–6–4 ...	86	14	15	31	24
Electric, 4–6–6–4...	82	14	15	31	21
Steam, 4–6–2 ...	88	39	42	66	61
Steam, 4–6–2 ...	83	21	22	66	55
Steam, 4–8–2 ...	72	21	25	66	59
Open-deck bridge, 56ft. span :					
Electric, 4–6–4 ...	80	49	55	39	42
Electric, 4–6–6–4...	90	39	46	39	32
Steam, 4–6–2 ...	72	59	68	88	67
Steam, 4–8–2 ...	57	35	42	88	63
Open-deck bridge, 122ft. span :					
Electric, 4–6–4 ...	87	26	27	28	24
Electric, 4–6–6–4...	98	18	20	28	22
Steam, 4–6–2 ...	86	29	30	45	52
Steam, 4–8–2 ...	70	28	32	45	47

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

GILDING METAL STRIP

No. STA 19. This is a further specification in the series relating to non-ferrous metals, which is being issued by the B.S.I. for the Ministry of Supply in order to co-ordinate the requirements of various Departments of the Ministry and also those of the Admiralty. The specification covers gilding metal strip used for bullet envelopes and includes requirements for the chemical composition which is set out in detail, and tolerances on the dimensions of the strip. Two hardness ranges of material are covered and separate bend test requirements are specified for each range. Requirements for grain size are also specified. Price 6d.

GLOSSARY OF TERMS USED IN ELECTRICAL ENGINEERING

No. 205, part 8. This publication forms Part 8 of the revised edition of B.S. 205, Glossary of Terms Used in Electrical Engineering. It is the concluding part of this glossary and contains an entirely new and fully cross-referenced alphabetical index to Parts 1 to 7 already published. The subjects covered by the whole series include General Terms (Part 1), Machines and Transformers (Part 2), Switchgear and Instruments (Part 3), Transmission and Distribution (Part 4), Electrochemistry and Traction (Part 5), Lighting and Heating (Part 6), Surge and Lightning Phenomena, Electric Lifts, Electric Welding, X-rays, Electromedical Terms and various (Part 7). Considerable alterations and additions have been made by the Committees charged with the revision, to keep pace with modern developments. Terms relating to telegraphy, telephony, radiocommunication, direction finding, and fire alarm, which were dealt with in certain sections of the 1936 edition, are not included in the new edition of B.S. 205, but will form the subject of a much enlarged edition of B.S. 204, to be issued shortly under the title of "Glossary of Terms Used in Telecommunication." Price 2s. each net.

BRONZE OIL-RETAINING BEARINGS

No. 1131. This War Emergency British Standard for the dimensions of bronze oil-retaining bearings has been prepared in collaboration with the Ministry of Supply and the three manufacturers of this type of bearing. Its primary object is to bring about a modification in the variety of types and sizes of bearings, and so to facilitate more rapid and economical production by concentrating the supply and demand on a simplified range of standard sizes. It relates to cylindrical bearings of nominal bores from ½in. to 2½in., and of various alternative standard lengths. Further specifications are to be issued later for flanged bearings and thrust washers.

SPOT WELDING FOR LIGHT ASSEMBLIES IN MILD STEEL

No. 1140. This specification relates to the application of spot welding to the fabrication of mild steel assemblies comprising two or more thicknesses of metal. The various applications have been classified under two broad headings, determined by the relation between the mechanical strength of the structure and individual welds ; the essential features of the types of welding machine for these two classifications are laid down. The specification defines the chemical composition for the parent metal and includes recommendations as to suitable steels. Price 2s. post free.

GALVANISED STEEL WIRE STRAND FOR SIGNALLING PURPOSES

No. 163, Part 1—1943. The first edition of B.S. 163 was issued in 1924 and unsatisfactory service led to a revision in 1936. This edition increased the elongation of the wire, but failures in service were not diminished, and, after review of all the available evidence, further revision was undertaken and has resulted in the publication of the present 1943 edition. The revision now published differs from its predecessors in that maximum elongation of reduced amount has been substituted for minimum elongation to ensure a high limit of proportionality to the wire and reverse bending is substituted for the previous torsion test. The four tensile ranges of 25/30, 40/50, 60/70, and 80/90 tons per square inch in the 1936 edition have now been reduced to three tensile ranges 50/60, 60/70, and 70/80 tons per square inch. Other changes are the stipulation of maximum sulphur and phosphorus in the steel and the provision that each wire shall be tested by the manufacturer as to tensile, reverse bending, and wrapping before stranding. The actual construction of the strand has been modified to ensure that the central wire shall be 0·003in. to 0·005in. larger than the six cover wires to ensure equal distribution of the load among all the seven wires when stressed in service and to provide definite, but restricted, flexibility to lessen any tendency to kink. Strand to the revised requirements has been tried out under service conditions for a reasonable period with, so far as is known, satisfactory results. Price 2s. net.

COLD TWISTED STEEL BARS FOR CONCRETE REINFORCEMENT

No. 1144. This specification is intended to fill a gap in the standardisation of materials for reinforcing concrete. Hitherto, reinforcement in the form of mild steel, high-tensile steel, and hard-drawn steel wire, and expanded metal were the only materials covered, the appropriate specification being respectively Nos. 785 and 405. There was accordingly a need for a specification for mild steel bars which have had their yield stress raised by cold twisting. The new specification provides for both single-twisted and twin-twisted steel bars, and the mechanical properties are laid down. Price 2s. post free.

TUBULAR STEEL SCAFFOLDING

War Emergency No. 1139. Two sizes of tubes for scaffolding purposes, a nominal 2in. diameter and nominal 1in. diameter tube, are covered in this specification. Details are given of the requirements with which the tubes should comply, both as regards their dimensions and mechanical properties. Tests are also included for the right-angled couplers to be used with these tubes. Price 2s. each.

The Engineer

DECEMBER, 31, 1943

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THE ENGINEER AS EMPIRE BUILDER

TO-DAY we conclude, for the time being at any rate, the long series on "Engineers and the British Empire." The articles were written at our request by Professor Middleton Smith, for a purpose which may have been almost hidden at times under the volume of material. Everyone who has given any study to the growth of the British Empire must have observed that it was acquired, for the greater part, in a casual manner, in "a fit of absent-mindedness," as it has been said. Military conquest has had far less to do with its acquisition than peaceful penetration, and its growth is due in an immeasurable degree to the work of engineers. That aspect is too often overlooked, and it was the purpose of our series to bring it into proper perspective. The historian is, unfortunately, all too rarely interested in technical works and technical progress. He concerns himself principally with diplomatic and military events and occasionally with the broader questions of commerce, as, for example, tariffs, cartels, and international trading agreements. But he nearly always overlooks the fact that unless the physical characteristics of new countries can be developed, growth and progress will not take place.

Thus it may be justly claimed that the engineer is the greatest pioneer of empires. Without his works backward lands would remain for ever backward. Their natural resources would be unused for the benefit of mankind, they would be subject to famine and disease, they would be split, from lack of means of communication, into diverse, ineffective, and warring communities, and would remain for ever isolated from the world and useless to it. It is the engineer who changes all that. He builds harbours and airports to connect the new lands with the old, he constructs roads and railways for internal and coastwise communication, he controls rivers and cuts canals, he drains marshes to improve health and encourage agriculture, and erects dams for the generation of water power. He delves deep into the virgin earth for minerals, and turns to profitable purposes the natural surface products. Furthermore, he sends out to the new lands machines from his factories, so that their indigenous resources may be developed, and in time he helps them to build up their own industries and to become contributories to the means through which and by which the lot of man is advanced. Without the aid of engineers all the work of statesmen and diplomatists, of armies and navies, would be a tinkling of cymbals—a thing of no account. The great adventurers may strike their flagstaffs into newly discovered territories and claim them for their own Crowns, but little or nothing will come of it till the engineers have followed the flag and have set about the great works which it is their destiny to perform. This fact, we say, is too often forgotten. Our histories tell us how this nation and that has acquired new domains, what wars have been fought for them, what subtleties of policy and diplomacy have been expended on them, what great speeches have been made about them, and what great books have been written around them. But very rarely does the historian condescend to notice that, lacking the brains, enterprise, and skill of engineers, their histories would begin and end in fruitless victories.

All this we have endeavoured to show in our series. We have taken the British Empire as, so to speak, an example. Professor Middleton Smith has set before us, with heartbreaking condensation at times, the works of the engineer in Canada, Australia, New Zealand, and South Africa and, summarily, in the Colonies. He has shown how the development of those countries has grown under the hands of the engineer and how, as they have grown, they have demanded ever more and more from him. Those who can read into his articles more than the mere dry facts will see in them a glorious history; a history far more glorious than those of armed conquerors; for the purpose of the engineer is ever to improve the lot of men and to ensure their happiness. He does not desire to overmaster and dominate them; he is no overlord, but a wise counsellor and doer of good, helping others to raise themselves and to move ever upwards into higher strata of culture, health, material comforts, and contentment. Of all empires that the world has ever known, we think it may be justly claimed that the British Empire has moved towards this high object with more toleration, with more consideration for other peoples, and with a greater willingness to loosen the bonds of control than any other, and that at all times and in all places it has sought to direct the works of engineers for the benefit of the original inhabitants as much as for its own advantage. Our record leaves much unsaid, many parts of the Empire still untouched. But nevertheless we hope it has shown that the true builder of empires is the engineer.

The Education Bill

THE new Education Bill is one of the first fruits of that planning for the post-war world to which so much thought has been given in many and diversified fields during the last twelve months. It had long been known that the Board of Education had such a measure under consideration and many of our major and minor institutions had given the matter attention and expressed opinions upon it. With the publication, some months ago, of a White Paper on Education, those interested were able to see upon what lines the Board was working, whilst the Board itself was able to judge from the reactions to the White Paper what modifications would be necessary in its plans if substantial agreement was to be reached. It may now be confidently predicted that, subject to modification in detail as a result of parliamentary discussion, the Bill will duly become law early in the New Year.

We do not intend to refer at length to the Bill's provisions. The greater number of them are in any case not directly of interest to engineers. As was foreshadowed by the White Paper, the school-leaving age is to be raised to fifteen and later to sixteen. In addition—an advance of at least equal importance—education is to be continued on a compulsory part-time basis up to the age of eighteen. Young people up to that age are to attend Young People's Colleges for a minimum of one whole day or two half-days per week. The Bill further lays it down that adequate and properly co-ordinated facilities for technical and adult education shall be provided and for the furtherance of that intention provides for the adjustment of the present system of local educational administration to meet the new requirements that will be thrown upon it. It is a matter of considerable gratification to engineers that the Board has yielded to the vigorous criticism that was directed against the financial provisions of the White Paper. The Bill accords substantially increased allocations of expenditure to technical education and notably accelerates the tempo at which it is intended the improvements shall be carried out. Though those concerned with technical education would no doubt have preferred a separate advisory body, the two Central Advisory Councils, one for England and one for Wales, which are to be established to advise the Minister on educational theory and practice will be welcomed, provided that

technical education is adequately represented upon them, the more so that the activities of those bodies are not to be limited only to matters referred to them. Taken all in all, though there are provisions in the Bill which can be subjected to criticism—Young People's Colleges, for instance, appear to be assigned the difficult task of giving sufficient vocational or technical instruction to distinguish them from existing schools without at the same time providing so much as to come into conflict with the technical colleges—the Bill undoubtedly marks a very significant advance.

But the Bill by itself, when it has become law, will not bring about the desired change. It will have provided only a foundation on which a more satisfactory educational system can be built up. Local authorities will have the duty of providing the desired adequate facilities for extended technical and vocational training, and they are bound under the Bill to consult with universities and other educational associations in their areas and with neighbouring authorities in drawing up satisfactory schemes for submission to the Minister. The success of any local scheme will thus depend to a very considerable extent upon the attention given to it by local educational bodies. The Bill provides the bones; local educationalists must see that they are clothed with satisfactory flesh. If that work is faithfully done, as we have every reason to suppose it will be done, this country, though more dependent than ever, as a debtor nation, upon its ability to export, should be provided for many years to come with an educational system fully consonant with its urgent need to produce engineering executives and craftsmen of a quality comparable with those of any other nation.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

AMALGAMATION OR CO-ORDINATION AND FEDERATION

SIR,—It is always a pleasure to correspond with one who allows that there is another side than his own, and the pleasure is enhanced when that one is willing to march part of the way of the other.

I think that Mr. Athoe will agree with me that, in attempting to lay down a principle, it must be one that allows no exception. I therefore must include all multiple bodies as subjects for fusion. So I should amalgamate not only architects, but also accountants, medical societies, land professions, and any other.

Not only is there the technical aspect to consider, but also the economic. Multiple associations are wasteful in buildings, in staffs, and in minor adjuncts. They involve different titles with different initials, confusing the potential employer.

If bodies are multiple, then a spirit of rivalry is engendered, which leads to friction and undignified publicity. It is well known that a chartered man thinks himself of higher rank than an incorporated one. All this is wrong. Sooner or later all cognate bodies will be fused and put on the same plane. The logical result of registration is fusion.

We have allowed these multiple bodies to arise without investigation or regulation of their origin. In the public interest, as well as their own, we must now fuse them and some duly constituted authority must control future formations. To rectify the present position we must proceed as the architects and dentists have done. We must put all practitioners who can show practical qualifications on the register and then close the doors except by examination.

There are extensive contacts between professional bodies which only those who have carried out some investigation know. Such are the relations between surveyors and lawyers, between barristers and solicitors, between doctors and nurses.

To systematise inter-professional relations I see no better body than a federation of all professions. The stimulus that was needed to create trade unions, namely, better wages (*inter alia*), is wanting in the case of professional men. There are no employers' associations to keep down charges in their case. The principles that have lain dormant in the pre-war world are now coming to the surface. They demand the substitution of order for chaos. They point to self-reformation. If this is not quickly forthcoming governments will intervene. Such is clearly the intention of the leaders of the New Order in world affairs.

A. W. CRAMPTON.

London, N.W.6,
December 24th.

ROCKET ATTACK

SIR,—In your leading article "Rocket Attack," which appeared in your issue of December 17th, it is stated that our aeroplane losses in attacks on Germany amount to about 5 per cent., whereas the losses on rockets would be 100 per cent.; but surely this is too favourable a comparison.

If one regards a bomber as a projectile which returns "to store," and assuming that its weight is in the neighbourhood of 10 tons net, and that it carries 2½ tons of bombs and 2½ tons of petrol, it starts off loaded at 15 tons. This means 33⅓ per cent. loss of material projected and to this must be added 5 per cent. for total loss of aeroplanes, making, say, 38 per cent., compared with 100 per cent. loss of rockets.

Am I right, or am I?

CONSTANT READER.

London, December 28th.

An Oil Engine Symposium

SHORTLY before the end of the year the Diesel Engine Users Association arranged an interesting symposium on post-war problems connected with the future manufacture and marketing of British-built oil engines. The meeting took place at Caxton House and the chair was taken by the President, Mr. A. K. Bruce, who was congratulated on his recovery from a serious illness. Mr. C. Pain dealt with the stationary type of oil engine from the point of view of the user, and called attention to the rivalry between two-stroke and four-stroke types and the competition between the oil engine and the gas engine. He also dealt with the design of parts, improved materials, lubricating oil consumption, and silencing. Mr. A. C. Yeates, of Crossley-Premier Engines, Ltd., said that during the last ten years the four-stroke engine had been developed along two lines, namely, higher speed and pressure charging. Pressure charging had also been applied to two-stroke engines. He thought that gas engines would be probably even more important after the war, as home-produced fuels would in many instances have to be used. He said that, whereas the oil engine depended on imported commodities, to the extent of 70 per cent. of the cost of the unit generated, the gas engine only depended on those commodities to the extent of 5 per cent. or less. The higher cost of fuel oil had made the gas engine economically advantageous under present conditions. Air-cooled pistons had, he reported, proved very successful. The case for the marine engine was well put by Mr. W. S. Burn, and Mr. J. Calderwood, of Sulzer Bros. (London), Ltd., replied. The importance of the trunk-piston type of engine working on the two-stroke principle was emphasised, and suggestions for new sizes were put forward. The development of oil engines for railway work was spoken of by Mr. T. Hornbuckle, who gave some interesting facts concerning railway requirements. Mr. L. N. Short replied and paid a tribute to the successful operation of British-built engines on railways abroad. A beginning was made with the discussion, and the Hon. Secretary, Mr. Julian Tritton, who recently returned from America, gave some account of the servicing of oil engine locomotives in the United States. The discussion was adjourned until some time in the New Year, and the date of the meeting wlil be announced.

American Electric-Furnace Steel

ALTHOUGH the annual output of electric furnaces in the United States has been increased by some 2,000,000 tons of ingots since 1940, there is still a shortage of "electrical" constructional steel. Much production has been diverted from basic electric to basic open-hearth furnaces, so that the former are now producing mainly high-grade steels for aircraft, guns, and tools. But the basic electric has advantages in rapid production, cleaner and more uniform output, maintenance of closer analysis limits, and high-grade steel produced from poorer quality of raw materials. Furthermore, such valuable oxidised elements as chromium, vanadium, manganese, and tungsten can be recovered with much less loss than in open-hearth practice. It appears that the electric furnace is not yet used to full advantage as a refining medium, for which it is ideal. With a modern cupola for melting scrap into hot iron which is charged with the ore to oxidise the carbon and phosphorus, this hot iron contains about 3·5 per cent. carbon and 0·125 per cent. phosphorus. Using 60-ton charges, high-grade steel may be produced at the rate of 20 tons per hour. The largest electric furnace plant now in operation is designed to produce 80-ton heats of aircraft steel from the molten product of a 200-ton tilting, open-hearth furnace. Another plant is using a combination of 130-ton cupolas, 12-ton converters, and 40-ton electric furnaces. There are three fundamentals in melting in the basic electric furnace. First, the combination of high degree of oxidation in addition to high lime in the slag and low temperature permits the elimination of phosphorus as calcium phosphate; secondly, after removal of the first slag, a second high-lime and low-silicon slag of low oxidising power, combined with high temperature, promotes low sulphur and equilibrium in the metal. The importance of this second slag is its high basicity and low oxidising power, a combination which permits of making steel under conditions where equilibrium is obtained with a minimum of products of oxidisation. Thirdly, with high temperature and an active bath, there is assurance of clean steel, while a dead-metal inactive bath of relatively low temperature gives steel high in inclusions and generally low quality.

SLUDGE-DRYING DEVELOPMENT AT CHICAGO.—The American Society of Civil Engineers has published a report on the capacity and operating experience of the South-West Treatment Works in the Sanitary District of Chicago. The South-West works serves an area of 82 square miles along the lower west and south sides of Chicago, and plant equipment includes a pump and blower house, preliminary settling tanks, sludge concentration tanks, and a combined sludge handling and steam generating plant. The prime movers, all driven by steam turbines, consist of four sewage pumps, three blowers and two electric generators. The plant effluent is used as condensing water in the surface condensers of the turbines. There are twelve preliminary settling tanks, and the detention period is thirty-four minutes at 400 million gallons daily.

The Electron Microscope and its Application to Engineering Problems

By A. G. QUARRELL

No. II—(*Continued from page 502, December 24th*)

AGE-HARDENING phenomena would appear to offer plenty of scope for the electron microscope, and Zworykin[3] has published photographs showing (1) precipitation of manganese in a fine-grained, rolled magnesium-manganese alloy, (2) lamellar precipitation in a magnesium-aluminium alloy, and (3) precipitation of beryllium along the lattice planes of an aged beryllium-copper alloy.

In spite of the valuable results so far obtained by the replica method, even the most ardent advocate of the electron microscope must admit that it would be preferable to examine metallic surfaces directly, and many attempts have been made. In the metallographic light microscope the opacity of the specimen is overcome by using either normal or oblique illumination. Attempts to use similar methods of illumination with electrons have failed, largely because the magnetic lens is only capable of focusing one wavelength, *i.e.*, electrons of one velocity, at a time. After reflection at a metallic surface, electrons which were previously homogeneous lose varying amounts of energy, and the resulting beam is polychromatic, leading to pronounced chromatic aberration in the image. Such chromatic aberration is ingeniously overcome in a scanning method suggested by v. Ardenne[9], in which the final image is not produced by magnetic lenses. In the electron scanning microscope a combination of magnetic lenses is used to concentrate an electron beam into a fine probe, 10^{-6} cm. diameter, and this is used to explore the specimen systematically. Wherever the electron probe impinges on the specimen surface secondary electrons are produced, whose number is a function of the condition of the surface at that point and may be regarded as a measure of the "brightness" of the surface. The secondary electrons are accelerated towards a fluorescent screen, where they generate a light signal which is used to activate the photo cathode of an electron multiplier. After suitable amplification the resulting current is used to operate the printer bar of a facsimile receiver which is synchronised with the electron probe scanning the specimen. In this manner a picture of the specimen surface is printed in about eight minutes. Micrographs so far obtained with this device show a resolution of 5×10^{-6} cm., but whereas with the orthodox electron microscope the photographic image may be further enlarged with advantage, this is not true of the picture produced by the scanning microscope, because the individual scanning lines can just be seen in the original. A picture of lightly annealed brass obtained by Zworykin, using a scanning microscope, is shown in Fig. 6.

A somewhat similar idea was put forward by Knoll and Theile.[10] In their method the object was mounted on a metal plate in a high-vacuum tube, the plate being connected to the control grid of a cathode ray oscillograph, whose deflector plates were coupled to the electron scanning arrangement so that scanning and recording beams were synchronised. The emission of secondary electrons from the object governed the intensity of the electron spot on the fluorescent screen of the oscillograph, and the structure of the object was reproduced in the image because of the differences in secondary emission between different parts of the surface.

The electron scan microscope has the advantage that it can be applied equally well to massive specimens as to thin films, and it might even be possible to examine objects in free air by scanning through a Lenard window. On the other hand, it would seem that the attainable resolution is always likely to be less than with the standard electron microscope, though sufficient to enable it to perform much useful work.

In addition to the microscopes so far discussed, there exist a number of instruments in which electrons are used to obtain an enlarged image. In some of these, high magnifications of very special objects may be obtained, whilst in others the magnification is not large, but the use of electrons instead of light greatly facilitates observations. L. C. Martin[11] has suggested that these miscellaneous electron-optical arrangements shall be classified as cathode microscopes, simple electron microscopes, and field emission microscopes. According to this classification the name cathode microscope is applied to any apparatus in which the cathode is the object and in which the image of this surface is formed on the screen by an electrostatic or electro-magnetic lens system. The magnifications attainable with microscopes of this type are, generally speaking, much smaller than in the case of the high-resolution instrument, but much valuable work has already been carried out with their aid, particularly on the cathodes employed in thermionic valves.

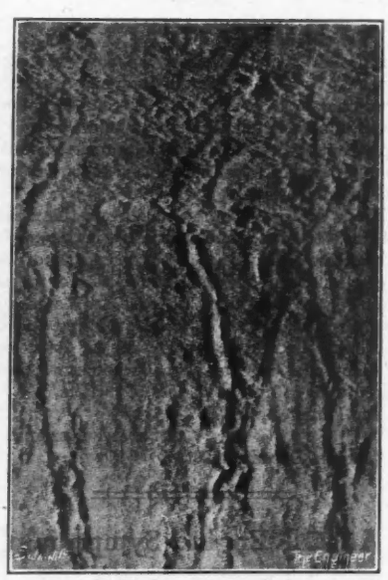

FIG. 6—ELECTRON MICROGRAPH OF ANNEALED BRASS

Cathode microscopes have been chiefly used in industrial laboratories where facilities are available for making cathode ray tubes, and the design usually adopted has been clearly influenced by this fact. The apparatus is frequently of all-glass construction and is sometimes sealed off so that only the one specimen can be examined. In some cases only magnetic lenses are used, but the fact that the object is self-illuminating and that an accelerating field must be provided for the emitted electrons enables some form of electrostatic lens to be used with advantage. The simplest form of electrostatic lens consists of a small hole in a conducting electrode which is itself too thick for the transmission of electrons. The electric field before and after the pinhole is different and the change in field may be regarded as taking place in the hole. The electric fields are axially symmetrical and the pinhole will therefore act as an electron lens. Although the single pinhole lens is little used, the double pinhole lens forms an immersion objective, which is useful for giving an enlarged image of a hot cathode at magnifications up to 200 diameters. The first pinhole is placed near the cathode and is maintained at a slight negative potential with respect to it, whilst the second pinhole is at a high positive potential and acts as the anode. So that the electron emission of the cathode shall not be restricted, the anode is placed very close to the first pinhole or grid and the hole in the grid is generally larger than that in the anode. The focal length of the immersion objective can be varied by changing the ratio between grid and anode voltages, and has a minimum value of about 1·5 times the diameter of the hole in the grid.

The resolving power of the electrostatic immersion objective is determined by the wavelength to be associated with the electrons emitted from the cathode. For example, electrons leave an oxide-coated cathode with initial velocities corresponding to about 0·1 volt and the corresponding de Broglie wavelength is of the order of 39 Angström units. Diffraction effects set a final limit to the resolving power available in any system, and the distance of separation d of two object points which can just be resolved in the image with a wavelength λ is given by

$$d=0\cdot61\,\lambda/\text{N.A.},$$

where N.A. is the numerical aperture of the lens. In the light microscope it is possible to obtain numerical apertures as large as 1·5, but in electron optical systems it is necessary to use much smaller values in order to keep lens aberrations to a minimum. In electrostatic lenses the numerical aperture may be as small as 0·001, which would give $d=2\cdot4\times10^{-3}$ mm. for a wavelength of 39 Angström units. In other words, the resolving power would be approximately one-tenth that of the light microscope.

In cathode microscopes employing only electrostatic lenses the immersion objective may be followed by a symmetrical lens. This contains three elements, the outer ones being at the same potential, which is generally less than that of the central electrode. The object and image are therefore in regions of the same potential, as distinct from the immersion objective, where the potential of the image space is much higher than that of the object space.

The cathode microscope is ideally suited for the investigation of electron emitting surfaces, and its application to a study of thoriated tungsten has greatly increased knowledge of the mechanism involved. Thoriated tungsten exhibits a very high thermionic emission, and Bruche and Johannson[12] were able to show that the thorium came to the surface only at a number of discrete points and that on further heating the thorium spread until the greater part of the surface was covered. It was at one time assumed that the thorium atoms arrived at the surface preferentially along the crystal faces, but closer investigation showed that

the thorium centres occurred indiscriminately over the surface, some on the crystal boundaries, others right within a crystal face. On gradual cooling of the cathode most of the thorium appeared to recede into the tungsten once more. Ahearn and Becker[13] confirmed most of these results, using a cathode microscope with a double pinhole electrostatic lens, and, in addition, they examined the emission from a single crystal filament. They observed alternate active and inactive bands parallel to the filament axis, eruption of thorium occurring only from the active bands. The surface migration of the thorium was strongly directional in the case of the single crystal, but isotropic with polycrystalline wires.

Work on activated cathodes showed that under suitable conditions the electronic emission was determined by the crystalline structure of the underlying metal, and Burgers and Van Amstel[14] took advantage of this to follow the transition from α to γ iron. In the cathode microscope which they employed magnification was obtained by means of a single shrouded electro-magnetic lens and the continuously evacuated instrument was of glass construction. The iron specimen was in the form of rolled strip and was made the cathode. The electron emission from the iron when it was heated by the passage of a current through it was insufficient to give an image and the surface was therefore activated with strontium. Under these conditions the electron emission from the strontium depends upon the orientation of the underlying iron crystal face, and the electron image formed on the fluorescent screen bears a marked resemblance to an etch figure, the various dark and light regions corresponding to differently orientated iron crystallites.

By successively raising and lowering the temperature of the iron specimen through the critical range it was possible to follow the $\alpha \rightarrow \gamma$ and $\gamma \rightarrow \alpha$ change. Owing to the existence of a slight temperature gradient along the iron strip the point at which the transition temperature had been reached gradually moved along the strip as the temperature was changed and the pattern therefore contained images of α and γ iron simultaneously. Transformation could be made to occur slowly by changing the heating current very gradually, and a cinematograph film was taken and shown at a London conference in 1937. The magnification employed was only 20 diameters, but the electron pictures agreed exactly with light pictures of the same magnification. In the electron image straight boundaries occurred, which were attributed to twinning, and the growth of twin lamellæ could be clearly followed on the screen.

The activation method employed in this work is open to the objection that the surface to be examined must first of all be covered with a monomolecular film of strontium or barium. In the case of tungsten, tantalum, molybdenum, and platinum-rhodium, however, the thermionic emission at temperatures above 1250 deg. Cent. is sufficient for electron images to be produced without prior activation of the surface, and much work has been carried out on tungsten wires. The work function of the metal depends upon the orientation of the crystal face at the surface, and electronic emission is therefore not uniform and the crystalline structure is reproduced in the image. Examination of tungsten wire in the cathode microscope shows that when this metal is heated the effects of mechanical working during manufacture of the wire or strip begin to disappear at 1250 deg. Cent., which is the lowest temperature at which the unactivated surface can be examined. Prolonged heating leads to crystal growth, and there is a tendency for a more homogeneous structure to be formed at the surface of the wire.

Application of the cathode microscope to metallic surfaces at ordinary temperatures is made possible by taking advantage of photo-electric emission. The electrons necessary for the production of the image may be excited photo-electrically by means of ultra-violet light or X-rays, but owing to the relatively feeble emission it is necessary to accelerate the electrons through at least 10 kV in order to provide sufficient energy to produce an image on the fluorescent screen. Since provision must be made for illuminating the cathode, the double pinhole lens cannot be used, and any magnetic lens must be some distance from the cathode and therefore high magnifications are not possible. In spite of this the method has certain advantages over the thermionic method. Using the photo-electric method of excitation, Pohl[15] has obtained electron images from a number of metal surfaces, whilst Mahl and Pohl[16] have observed the mechanical deformation of tin about to melt in a molybdenum crucible.

Decreasing the work function by covering the surface with a thin layer of one of the alkali metals, for example, increases the photo-electric emission so that weaker illuminations and lower accelerating potentials are possible. Gross and Seitz[17] have thus activated the surfaces of nickel and silver specimens by evaporating a thin layer of barium on to them, and they have obtained images with the metals at various temperatures.

In simple electron microscopes no lenses are used for the production of the image, but advantage is taken of the rectilinear propagation of electrons under suitable conditions to produce an enlarged shadow image. Morton and Ramberg[18] have described a simple electron microscope in which they irradiated the object with the divergent beam of cathode rays from an extremely small cathode. The magnification obtained in the shadow image on the fluorescent screen depends upon the distances from cathode to object and from object to image.

In other versions of the simple microscope the cathode is made self-illuminating by reason of thermionic or photo-electric emission and the electrons are accelerated towards the fluorescent screen in straight lines. If plane parallel electrodes are used there can be no magnification, but with coaxial cylinders, although the magnification parallel to the axis is unity, the azimuthal magnification is given by the ratio of the two radii and when the cathode is in the form of a fine wire this ratio may be very large. Microscopes with cylindrical symmetry have been used to study the thermionic emission of thin wires, and once the individual crystals have become large enough to show up on the fluorescent screen it has been possible to follow the recrystallisation in such wires. When ordinary drawn wire is used the image is invariably streaked with bright longitudinal lines due to die marks, and if recrystallisation is to be investigated the surface must first be rendered smooth by abrasion or some similar process.

If the electric field at the surface of a metal is sufficiently high, electronic emission occurs even in the cold, and Muller[19] took advantage of this to obtain enlarged images of metal surfaces using a simple microscope of hemispherical symmetry. By reducing the radius of curvature of the specimen the field at the surface increases until, with a fine point, it is possible to draw field currents large enough to excite visible fluorescence using only moderate applied voltage. Muller was able to produce images of an etched tungsten single crystal point at magnifications as high as 100,000. He was also able to show that the field electrons had an angular distribution characteristic of the crystal structure of the metal.

Benjamin and Jenkins[20] have extended Muller's work, using a spherical bulb to observe more of the wide angle beams than was possible with Muller's apparatus. A fine point was produced on a tungsten wire by etching and was then supported at the middle of a V filament through which a current could be passed to heat the tungsten point. The filament was placed in a highly evacuated spherical glass bulb in such a position that the point of the tungsten was at the centre of the bulb. Electrolytic etching of the wire enabled points of radius $2{\cdot}5 \times 10^{-5}$ cm. to be obtained, and application of 5 kV was sufficient to cause field emission. One-half of the bulb was coated with a conducting film of graphite to act as anode and the other with a fluorescent powder. Assuming that the electrons leave the point normal to the surface and travel in straight lines to the fluorescent screen, the magnification should be equal to the ratio of the radius of the bulb to that of the tungsten point, which in the apparatus of Benjamin and Jenkins would be 200,000. This magnification should make it possible to distinguish small groups of atoms, and this was claimed in the examination of activated specimens.

The patterns obtained with the field emission microscopes consist of a symmetrical arrangement of light and dark areas, and it was found that the centres of the dark spaces could be identified with the directions of the normals to the main crystallographic planes. When the tungsten was heated to red heat the pattern broke up into a mass of small spots about 1 mm. diameter, which executed random motion. This motion increased with the temperature and was attributed to the movement of groups of atoms over the surface of the point. By making use of a barium source inside the bulb it was possible to use the microscope to follow the formation of a monomolecular layer of barium over the point.

There are many features of the patterns obtained with the field emission microscope which are not yet understood, and the method is at present confined to the examination of exceedingly fine points, but it has the advantage that the specimen can be examined at room temperature, no lenses are used, and therefore the full resolving power associated with electrons should be attainable in practice.

Conclusion

The development of the replica method for the examination of etched metal surfaces with the high-resolution electron microscope has opened up new fields for investigation, and it may confidently be expected that in the future the replica method will be still further improved and its application to the study of metals will add greatly to our knowledge and lead to the production of yet better alloys for engineering purposes. The scanning microscope is in its early stages, but it would seem that its further development will be closely linked with progress in the television field, and in a few years it may surpass the orthodox instrument in general usefulness. The cathode microscope is particularly suitable for following high-temperature transformation and recrystallisation, but further work on the activation of surfaces to show up their crystalline structure is necessary before the cathode microscope can be used extensively for this purpose. Simple and field

emission electron microscopes are of less general application, but they are interesting because they illustrate the wide variety of methods of examination which are possible when electrons are used for illumination.

When it is remembered that the development of the electron microscope has taken place in the last ten years it will be realised that progress has been rapid, but the limit of resolving power set by diffraction of the de Broglie waves is still far from being attained, and there is therefore plenty of room for further advances. In its present stage of development the high-resolution electron microscope can justify a place in any modern metallurgical research laboratory, and an additional attraction is that the same instrument may be used for the examination of surface films by the electron diffraction method.

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South African Engineering Notes

(By our South African Correspondent)

CAPE TOWN, October.

Drilling for Oil

THE Government of the Union of South Africa is about to initiate an extensive programme of drilling for oil in various parts of the Karoo and Free State. This programme gives practical effect to the announcement made by the Minister of Mines, Colonel F. C. Stallard, in Parliament last session that the possibility of oil occurring in the Union merited the fullest investigation.

Colonel Stallard recently stated that the oil occurrences do not amount to a probability, but to a possibility which is so distinct that a full and scientific investigation should be carried out. "All the available data, old and new, have been correlated, and the stage has now been reached where drilling can be carried out to investigate the actual field conditions. Our experts have selected certain chosen sites where boring operations will soon begin." The Minister added that the investigation would take time and that early results must not be expected.

Tungsten Development

Good progress, the Minister said, is being made in the field development work for tungsten, one of the Union's strategic base metals. Tungsten occurs in Natal and on a larger scale in Namaqualand. Parties are now covering these areas prospecting in search of the mineral. While progress is slow, a substantial advance was made recently when the large-scale presence of tungsten was discovered. Colonel Stallard also said that South Africa was producing enough mercury for its own requirements. Production began soon after the war started, and it was financed chiefly by the Department of Mines under its Small Mines Assistance Scheme.

War Supplies from the Union

South Africa is to be called on to supply more than ever to meet the needs of her own Army, as well as those of the United Nations operating in the eastern theatres, according to a bulletin issued by the Director-General of Supplies early this month. Important conferences with high officers of the British Ministry of Supply and the British Army have recently been concluded in Johannesburg, as a result of which increased orders for technical production are likely to be placed with the Union. The diversity of the goods the Union is supplying to other Allied Governments emerges from an examination of recent inquiries and orders received from other countries by the Director-General of Supplies organisation. These include 38 tons of copper wire, 10 tons of chrome canning salts (the production of which has been developed in the Union through war demands), 10,000 ampules of dysentery sera and 45,000 of diphtheria anti-toxin, more than 2000 electric alternators, motors, and transformers, and more than 400 tons of first-grade dry yellow ochre powder. There has also been a demand for more than 250,000 pairs of shoes for the R.A.F., in addition to very extensive orders on hand for Army boots for the United Nations Forces. The Union's external military supplies have in the past three years run into tens of millions of pounds' worth of goods; apart from boots, blankets, clothing, food, and the vast field of engineering supplies, from aeroplane hangars to bridges, a great many products important to the Union's industrial and agricultural economy have been purchased for use in other theatres of war.

War production plants in all parts of the world have called for very large quantities of South African industrial diamonds, to be used as cutting tools and as abrasives and polishers, as well as drills. In the four years of war the Union has exported more than 4 tons of diamonds.

The Union is at present engaged on its biggest statistical job. At the request of the United States Government, the D.G.S. organisation is now "programming" the whole of the country's requirements for the remainder of 1943 and for 1944. Under the heading of Preserved Food Production in South Africa, the bulletin gives the country's canning programme in the coming twelve months as 225 million pounds of jam and marmalade, 40 million pounds of canned fruit, 55 million pounds of canned vegetables, and 50 million pounds of canned sausages, fish, and milk. From these supplies the Armies of the Union and the Allies, the Royal Navy, merchant ships calling at South African ports, and the civilian population will draw their requirements. Certain supplies will also be made available for other African territories.

South Africa Builds Warships

After a lapse of 100 years, shipbuilding for the British Navy has been resumed at Knysna in the Cape. When the war began the firm of Thesen and Co., well known in the shipping world and large timber merchants and furniture manufacturers, felt they were not justified in keeping their large factory at Knysna employed on non-essential work, and decided to close down for the duration. No sooner had they done so, however, than they were approached by the Admiralty and asked to reopen and turn the factory over to boat and shipbuilding. The factory was ideally situated for the purpose—alongside the wharf and the deep water—and the process of conversion started immediately. Oaks planted by George Rex, at one time Marshal to the Admiralty at Cape Town, on his estate at Knysna more than 100 years ago, and stinkwood, a remarkably durable wood, which grows in the Knysna forests, are used for making essential parts of the boats, and several have been completed. Built to Admiralty designs, these boats are described as miniature destroyers by the naval authorities. Their primary duty will be to act as an anti-submarine striking force. They are 75-tonners, 112ft. long. The engines, armament, and fittings are shipped to Knysna from Britain. These "destroyers" are operated by the Royal Navy, and the senior officer of each flotilla is a Lieutenant of the Royal Naval Volunteer Reserve. All the other officers belong to the S.A.N.F. All the officers receive special training before being sent to join the South African flotillas. The ratings are nearly all South Africans who have served in the Royal Navy since the first months of the war.

For their size and speed, these patrol craft are remarkably well armed, and can deal with surface craft, aircraft, and submarines. They carry depth charges and a Y gun for firing them. If necessary, they can fire torpedoes.

Survey of South African Industry

The Board of Trade and Industries is about to embark on a comprehensive investigation into the manufacturing industries of the Union, which will probably be one of the most important of its kind ever undertaken. The Board's report may form the basis of a "charter" for South African industries for many years to come. The scope of the investigation will be appreciated from the terms of reference. They include the extent to which manufacturers are engaged in war production and the possibilities of directly changing over to peacetime production at the end of the war, as well as the prospect of absorbing labour into the industry after demobilisation; all matters directly and indirectly affecting the economics of production and distribution and the possibilities of rationalising and regulating through a licensing system; the best method of dealing with dumping and disruptive competition after the war; the effects of manufacturers' or distributors' associations, combinations and monopolistic tendencies on production, distribution, market demand, and/or consumers' prices; the possibilities of developing the export trade in manufactured goods to African and other territories; the best way of disposing of surplus Government stocks after the war, having regard to the interests of producers, distributors, consumers, and the State.

The object of the investigation is two-fold. It is, first, the desire of the Government to have before them all the facts bearing on the South African industrial position, and to get as complete as possible a picture of the manufacturing industries. The other object is the wish of the Government to have all the facts affecting the manufacturing industries in view of wartime developments, and those likely afterwards, so that it can formulate its future industrial policy and ensure development along sound lines in the interests of the country as a whole.

Union Engineering Industry Transformed

Machine tools worth more than a million pounds have been brought to the Union since the outbreak of war. Many of them are of a type hitherto not imported—production machine tools, as distinct from machine tools for maintenance and repair working. By the importation of these tools a transformation has come to the South African engineering industry. Its shops are now more diversely equipped than ever before. A very large number of South African men and women have gained experience in the use of modern machines in mass production. Engineering and other manufacturers throughout the Union are engaged on a big programme for the production of agricultural implements—the biggest ever undertaken. The programme includes production of ploughs, harrows, planters, cultivators, and a great variety of other farming implements and spares. The output of one concern now exceeds 500 tons monthly. A standard design for a two-furrow plough has been decided on, and is to go into mass production. South African steel is to be used and the prices will be almost as low as those of the articles shipped from overseas.

Manufacturers in the Union are still busy with war orders for the Allied Nations, and expect to be working to utmost capacity in the near future, as with the war against Germany nearing new heights of intensity, with its approach to that country and the opening of large-scale operations against Japan, the demands upon South Africa from the Allied Nations will tax this country's resources to the utmost. Manufacturers here are also finding that they are being asked to supply a much larger variety of goods. At the moment the Union is arranging to supply 450 tons of rubber. The rubber is being obtained from the landolphia vine, of which cultivation has begun with enthusiasm, and excellent results—the output is expected to be increased to about double at the next yield.

A Survey of Plastics*

By S. LIVINGSTON SMITH, D.Sc. (Eng.), M.I. Mech. E.†

(*Continued from page 512, December 24th*)

IV.—Reinforced Plastics as Structural Materials

The chief potential advantage of synthetic materials lies in their adaptability to the special circumstances of each particular case, and the possibility of plastics as structural materials must be examined from this aspect.

(1) *Ties.*—Considering the figure for the specific tensile strength of, say, "Gordon Aerolite" (Table VI), the material appears to be ideal for carrying tensile loads. However, owing to its weakness in shear, it becomes very difficult to stress fully a tensile member without rather large end fittings. The weight of end fittings will be independent of the length of a tie, and so will be negligible in the case of a very long tie, but prohibitive in the case of a short one. Thus, in designing the lightest tie to carry a given load, the material selected will depend on the length of the tie, as those with the highest tensile strength are not generally those capable of withstanding the highest shear stresses.

(2) *Struts, Beams, &c.*—In general, the main advantage of plastics lies in their use in cases where design is limited by elastic instability rather than material strength. For example, in metal aircraft, loads to be carried are often so low as to call for very thin sheets which have to be stiffened with ribs and stringers, and are even then liable to buckle before the material can be fully stressed. Again, such thin sections are liable to vibration and accidental damage.

If, however, a material of lower density can be used, sections can be made thicker for the same weight, flexural rigidity (as measured by E I in the conventional notation) being increased in greater proportion. As flexural rigidity is the factor which determines the resistance to buckling of struts, compression flanges of beams and shear members, the material having the highest value of E/ρ^3 (Young's modulus/density cubed) will be the best. Table XI compares

Table X.—*Comparison of Materials for Specific Stiffness and Flexural Rigidity*

Material.	Young's modulus E, lb. per sq. in.	Density ρ, gm. per cu. cm.	$\frac{E}{\rho}$	$\frac{E}{\rho^2}$	$\frac{E}{\rho^3}$
Steel...	30×10^6	7·8	$3{\cdot}85\times10^6$	$4{\cdot}93\times10^5$	$6{\cdot}31\times10^4$
Aluminium alloy	$10{\cdot}8\times10^6$	2·8	$3{\cdot}85\times10^6$	$13{\cdot}78\times10^5$	$49{\cdot}3\times10^4$
Laminated paper-base sheet	3×10^6	1·47	$2{\cdot}04\times10^6$	$14{\cdot}4\times10^5$	$94{\cdot}6\times10^4$
Unidirectional "Gordon Aerolite"	7×10^6	1·47	$4{\cdot}86\times10^6$	$33{\cdot}6\times10^5$	$220{\cdot}0\times10^4$

several materials from this point of view. Where the nature of the compression member is such that it may collapse in any direction the figure of merit becomes E/ρ^3.

Thus what is in effect an expansion or "blowing out" of a material (*i.e.*, from the point of view of stiffness, aluminium alloy is equivalent to an expanded steel) can lead to lighter structures less likely to buckle; and the table shows that the reinforced plastic materials offer considerable promise.

(3) *Sandwich Structure.*—The effect of expansion or "blowing out" may be brought about by using a sandwich construction in which stiff skins are placed on each side of a lighter filler material, the object of which is to retain the skins in their correct relative positions and to prevent them from crinkling locally. Synthetic filler materials or elastic stabilisers are now being developed, but balsa wood, which weighs from 5 lb. to 8 lb. per cubic foot, is used as a filler in the sandwich construction of the "Mosquito" aircraft.

It will be clear that sandwich construction is not universally applicable and the advantages to be derived from its use are greatest where a component has to carry a low compression load over a great length. Where high compressive loads have to be carried over short lengths and there is no risk of buckling, the solid material will be as good as a sandwich.

V.—Use of Plastics in Bearings

(1) *Water-Lubricated Bearings.*—The outstanding advantage of plastic bearings is that they can function satisfactorily under high-duty conditions when lubricated with ordinary tap water. Water can, of course, act as a lubricant for any materials, provided the operating conditions are such as to permit the formation of a fluid film. Its viscosity is, however, so small as compared with lubricating oil that in most cases a fluid film would not be formed and a condition of boundary lubrication would exist. In such cases the nature of the bearing surfaces, as well as the chemical structure of the lubricant, influence behaviour; and if water were used to lubricate, say, steel and phosphor-bronze under conditions of high load and low speed, seizure and tearing of the surfaces would result. Under such conditions, however, bearings made of laminated fabric-base phenolic material show up to great advantage.

The exact mechanism which renders this result possible is not known, but it is suggested that the cellulose fibres impregnated with water form a boundary layer similar to that formed by the polar molecules of an ordinary lubricating oil on a metal surface. These molecules are usually conceived as being rigidly attached to the metal surface at their active ends and, if strongly polar, as standing out normal to the surface—like the pile on a carpet or a field of corn—thus providing a protective layer on the bulk materials and reducing the forces of attraction of the opposing surfaces by increasing the distance between them.

Various experiments have been carried out at the National Physical Laboratory and elsewhere which, together with the experience of many operators, clearly demonstrate the superiority of such bearing bushes over metal ones under boundary lubrication conditions, provided that sufficient water passes through the bearing to remove the heat generated by friction, thereby preventing charring of the plastic surface. In the case of rolling mills the ample supply of water necessary to remove this heat is useful also as a coolant for the rolls themselves.

Advantages claimed by operators are (i) ability to withstand shock loading, which, with metal bearings, results in surface cracking; (ii) lower friction losses than with metal bearings; and (iii) very high resistance to wear—probably because seizure cannot occur.

However, there are two distinct disadvantages associated with plastic bearings, namely (i) low heat conductivity, and (ii) dimensional instability in the presence of water. The first of these can be overcome by using sufficiently high rates of lubricant feed, but the second at present limits the use of such bearings to applications where small clearances and completely cylindrical bushes are not necessary.

In applications where 360 deg. bearings are required, and where the plastic is contained in a steel housing, it has been found necessary to allow as much as 0·006in. clearance per inch diameter in excess of the normal running clearance to allow for the swelling of the plastic material. Where oils and greases are used as lubricants, as is sometimes the case with very heavily loaded rolling mill bearings, dimensional changes are less, but still of sufficient magnitude to be troublesome when thick liners are used.

(2) *Aero-Engine Bearings.*—A recent report from Germany describes an aero-engine in which thin layers, about 0·2 mm. thick, of resin-bonded fabric were wound round and bonded to steel journals and run in steel housings. The lubricant used was normal engine oil and it is claimed that the engine ran for over 200 hours at ratings up to 80 per cent. of maximum output without appreciable deterioration of the bearing surfaces. Whilst this development may have been dictated by shortage of other materials, it illustrates the wide field open to plastic bearings, and it is possible that certain corrosion difficulties encountered with the usual bearing materials may be overcome by their use.

(3) *Cages for Ball Bearings.*—In certain applications of ball bearings the cage is the critical component and, if there is a temporary breakdown in lubrication, a metal cage may seize on the balls or races, completely wrecking the bearing. Such seizure is less likely to occur if plastic cages are used. These are sometimes machined from laminated tube.

VI.—Testing of Plastics

(1) *General.*—If the engineer is to consider the use of plastics in stressed parts he will require more complete and certainly more accurate mechanical data than are at present generally available. The behaviour under stress of all plastic materials is very different from that of metal, as will be understood when it is recalled that their structure consists of long chains held together by secondary forces as compared with the crystalline structure of metals. This difference is reflected in the methods necessary to secure accurate test data. Thus, plastics seldom exhibit a marked yield point; they tend to creep at normal temperatures, and they fail to obey Hooke's law precisely.

In testing plastics, one must also bear in mind the effect of moisture content and temperature. Great care is necessary to subject test pieces to a standard conditioning treatment before test. It is also necessary, if the test is to occupy any length of time, to arrange for constant conditions of temperature and humidity in the testing laboratory. No national standard has yet been agreed upon, although the National Physical Laboratory has adopted 55 per cent. relative humidity and 21 deg. Cent. as standard testing conditions.

(2) *Laminated Sheet.*—A description of the testing methods rendered necessary by the peculiarities of all the different types of plastics would form a paper in itself. The following remarks will therefore be confined to the testing of laminated sheet as a representative example of a plastic product.

(*a*) *Tensile Test.*—Whereas the tensile test is the simplest of all tests, very wide variations in the measured strengths of plastics will be obtained unless the following points are observed: (i) Condition of test pieces; (ii) finish and accuracy of preparation of test piece; (iii) alignment of test piece in testing machine; and (iv) rate of strain or of application of stress. No standard conditioning treatment has yet been generally adopted, but most specifications call for treatment for a prescribed period at a prescribed relative humidity and temperature. It will be realised that such treatment is of little value unless a condition approaching equilibrium is reached. The difficulty, at present unsolved, is that the time required to bring about a reasonable approximation to equilibrium is too long for practical purposes.

Test results are seriously affected if unskilled labour is used to prepare the test pieces, but if machine shop methods are used and the machining operations are carried out in the correct sequence no difficulty should arise on this account.

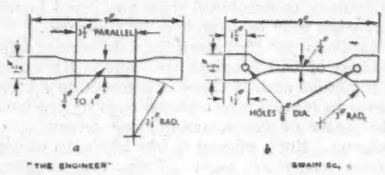
The importance of correct alignment in the testing machine arises from the lack of ductility of most plastic materials and neglect will cause low results to be obtained. Whether rate of strain or rate of increase of stress is adopted depends upon the nature of the testing machine. Whereas rate of strain is the ideal, all that can be defined in practice is rate of movement of the head of the testing machine. Rate of increase in stress is, however, more easy to achieve accurately. It is often inconvenient to alter the rate of application of load to suit different areas of cross section of test piece; but, as there is no appreciable necking of these materials, a precise figure can be quoted.

The tensile test called for in British Standard

* Institution of Mechanical Engineers, December 10th. Abstract.

† Superintendent, Engineering Department, National Physical Laboratory.

Specification No. 972—1941, which applies to fabric-base laminated sheet, is made on a test piece of the form shown in Fig. 10. This specification attempts to control strain rate by stipulating that load shall be applied steadily at such a rate that the minimum specified breaking stress is reached in approximately two minutes from the initial application of load. The



(*a*) Tensile test piece from British Standard Specification No. 972—1941.
(*b*) Another type of tensile test piece.

FIG. 10—*Tensile Test Pieces for Laminated Sheet*

specification goes on to state that special care is necessary to secure correct alignment of the test piece. As one cannot be certain of good alignment when using wedge grips, an alternative form of test piece has been suggested as shown in Fig. 10. Here load is applied by pins through two holes. An advantage of this type is that, if the holes are drilled first, they may serve to locate the test piece in a jig so that correct machining may be facilitated.

(*b*) *Extensometer Tests.*—The extent to which laminated material obeys Hooke's law depends very largely on the nature as well as on the water content of the sample. Figs. 11–13 show the behaviour of a low-grade cotton fabric laminated sheet. Laminated sheet may be made which is very much better than this, but the figure serves to show the sort of behaviour

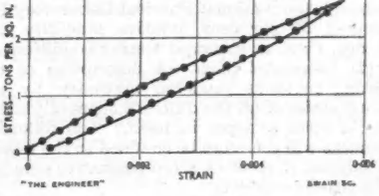


FIG. 11—*Tensile Stress-Strain Diagram*

which must be guarded against when testing and, indeed, when using laminated sheet.

Fig. 11 shows the result of an ordinary extensometer test. It will be noted that the loading line is curved, and that there is marked hysteresis. Experiments have shown that such hysteresis may remain even after a test piece has been subjected to six million repeated applications of the stress range 0–0·4 ultimate stress.

Fig. 12 illustrates the behaviour of this material when subjected to prolonged loading and subsequent removal of load. Creep takes place at comparatively low stresses, and an

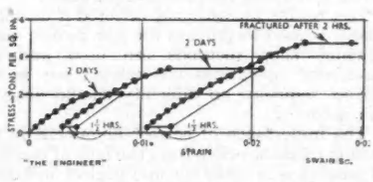


FIG. 12—*Prolonged Loading Tests; Tensile Stress-Strain Diagram*

appreciable amount of recovery takes place on removal of load.

Fig. 13 shows a family of creep curves relating to this material.

It will be apparent that it would be impossible accurately to quote a modulus of elasticity for such a material, and recourse must be made to some convention. Fig. 14 illustrates four possible conventions.

(*c*) *Compression Tests.*—British Standard Specification No. 972 calls for a proof compression test on a 1in. cube of material. A bedding-down load of 300 lb. is applied perpendicular to the laminations, followed by a proof load of 10,000 lb. The deflection consequent on the application of this proof load is not to exceed 0·04in.

When tests on cubes are carried to destruction failure usually takes the form of shearing on planes inclined at 45 deg. to the laminations.

A test which has been found useful at the

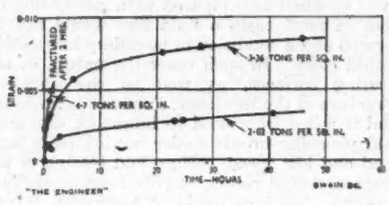
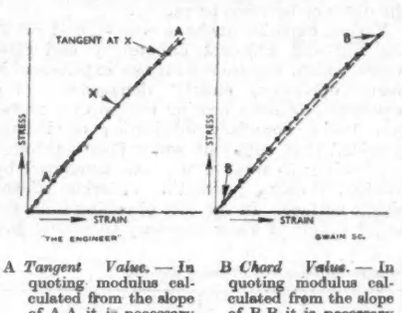


FIG. 13—*Prolonged Loading Tests: Creep at Constant Stresses*

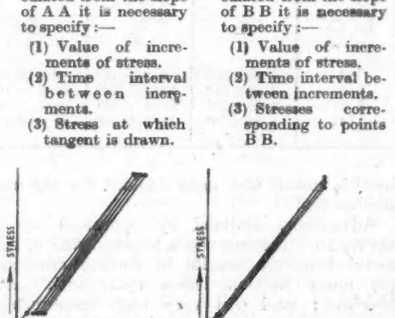
National Physical Laboratory consists of compressing a test piece in a direction parallel to that of the laminations. The height of this test piece is three times its thickness, so that it is somewhat slender and therefore sensitive to shear weakness. Care is necessary to secure good alignment. The ends of the test piece are ground square and parallel and the tests made in the axial loading shackle shown in Fig. 15.

(*d*) *Shear Test.*—It is very difficult to measure shear strengths accurately, and Fig. 15 shows



A *Tangent Value.* — In quoting modulus calculated from the slope of A A it is necessary to specify:—
(1) Value of increments of stress.
(2) Time interval between increments.
(3) Stress at which tangent is drawn.

B *Chord Value.* — In quoting modulus calculated from the slope of B B it is necessary to specify:—
(1) Value of increments of stress.
(2) Time interval between increments.
(3) Stresses corresponding to points B B.



C *Repeated Stressing.*— In this method stress is varied between a higher and a lower value until change in strain remains constant in successive cycles. In quoting modulus, it is necessary to specify:
(1) Range of stress.
(2) Time interval.

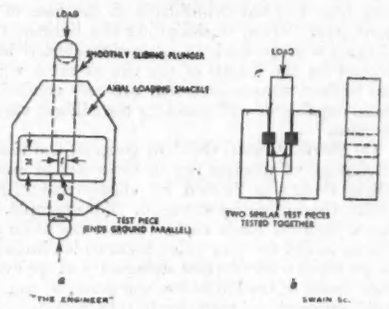
D *Repeated Straining.*— This method is similar to method C, excepting that a predetermined strain is applied to the test piece, successive loadings being varied to effect this. It is necessary to specify:
(1) Strain limits.
(2) Time interval.

FIG. 14—*Methods of Defining Modulus of Elasticity in Non-Hookean Materials*

the method at present used in the National Physical Laboratory. Small test pieces are fitted carefully into the slots in the device, which is then placed in a testing machine.

(*e*) *Impact Test.*—Whereas the impact test is used a great deal for roughly assessing the quality of moulded materials, its significance when applied to laminates is questionable. In the first place the excess energy method of test measures the total energy involved in fracture; what is really required is the energy of a blow to cause damage. Again, it is very questionable if the energy credited to the test piece is in fact absorbed thereby, and it is known that variations in the design of a testing machine cause different results to be obtained in impact testing. Probably the best test is an impact proof stress, wherein a blow of specified energy would be applied by dropping a ball or tup from a predetermined height on to a test piece, the material of which would be rejected if damgae resulted.

(*f*) *Creep, Fatigue, and Effect of High and Low Temperatures.*—Whereas it is important that knowledge be obtained of the properties of plastics under fatigue, prolonged loading, and high and low temperatures, before plastics can be used with confidence, special methods of test have not yet been evolved and the techniques which have been used for metals are employed subject to added precautions rendered necessary by the hygroscopic nature of plastics. Also, the high internal damping (consequent on



a Compression test. *b* Shear test.

FIG. 15—*National Physical Laboratory Compression and Shear Tests for Plastics*

the hysteresis) may give rise to overheating during a fatigue test unless conditions of test are selected with care.

VII.—Conclusions

From the foregoing it will be concluded that the range of materials generally referred to as plastics embraces a wide field of products with properties that can be varied to suit different applications. From the point of view of the mechanical engineer plastic products may be roughly divided into two groups. The attractiveness of the first is primarily ease of production of large quantities of insulating, non-corroding components, light in weight, but of no great strength. The second group, the reinforced plastics and laminated woods, in addition to being light and non-corroding, offer possibilities of considerable saving in weight. Much emphasis has been placed on this latter group, inasmuch as weight saving is attractive in such applications as transport, and indeed in those stationary structures whose main strength is necessary to carry their own weight. It will be apparent, however, that much more research is necessary to enable the full strength of fibres to be employed, to improve serviceability, and to facilitate cheap and easy production of small quantities. It is essential that both engineers and chemists should play a full and equal part in such research and the author would instance, as an example, the happy collaboration which exists between the Chemical Research Laboratory and the Engineering Department of the National Physical Laboratory in this respect.

The attention of readers is called to the fact that the illustrations Fig. 1 (December 17th, page 491) and Fig. 3 (December 24th, page 511) have been in error transposed. A comparison of these diagrams and their captions will at once make the matter clear.

AUSTRALIA LAUNCHES NEW INDUSTRIES.—At a cost of £1,100,000, two new industries are being established in South Australia by the Commonwealth Government. One is a £600,000 plant for reforging scrap steel, and the other is a £500,000 chemical plant, which will be used after the war for the production of fertilisers.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer.

Fall in United States Scrap Stocks

According to a statement issued by the United States Bureau of Mines, the domestic stocks of iron and steel scrap at consumers', suppliers', and producers' plants at the end of September, 1943, approximated 6,613,000 tons, representing a decrease of 2 per cent. from the 6,778,000 tons reported on August 31st. This decline was occasioned by decreases of 2 and 3 per cent. in consumers' and in suppliers' and producers' stocks respectively. Thus, while suppliers' and producers' stocks on September 30th, 1943, amounted to 1,139,000 tons, compared with 1,169,000 tons at the end of August, consumers' stocks were 5,474,000 tons and 5,609,000 tons respectively. The greater part of the decrease in total stocks was contributed by a decline of more than 3 per cent. in stocks of purchased scrap at consumers' plants (approximately 140,000 tons). The total consumption of ferrous materials (scrap and pig iron) amounted to 9,228,000 gross tons in September, representing a decline of approximately 1 per cent. from the 9,306,000 tons consumed in August. This decline was entirely due to the shorter month, since the average daily melt increased 2 per cent. over that in August. Although the total consumption of purchased scrap remained approximately the same in September as in August, stocks of this material at consumers' plants showed a decline of 3 per cent. This would indicate that shipments of scrap to consumers by suppliers and producers are insufficient to meet current requirements. While the total consumption of home scrap and pig iron in September showed individual declines of 1 per cent. from that used in August, stocks of pig iron gained 2 per cent., whereas stocks of home scrap remained approximately the same. In September open-hearth furnaces consumed 55 per cent. of the purchased scrap, 73 per cent. of the home scrap, and 79 of the pig iron used. In 1942 the percentages were 59, 71, and 77 respectively. In September Bessemer converters used 5·5 per cent. of the total scrap and pig iron charged to all furnaces, with open-hearth furnaces using 72·1 per cent. Steel-making furnaces, open-hearth, Bessemer, and electric furnaces accounted for 69 per cent. of the purchased scrap, 83 per cent. of the home scrap, and 89 per cent. of the pig iron consumed in September. The remainder was principally used in cupola iron-making furnaces.

The Pig Iron Market

Compared with a year ago, conditions in the pig iron market show a remarkable change, and since this is largely due to the changed situation of the chief consuming industries, it is of some significance. Last year at this time foundries, particularly those allied to the engineering industry and the jobbing foundries, scarcely knew where to obtain the supplies they required to deal with the huge amount of Government work upon their books. Now there is plenty of pig iron available for all consumers, with the noticeable exception of hematite pig iron. Some of the engineering foundries and jobbing foundries are endeavouring to obtain new business, as, although they are assured of employment for several weeks, cancellations and suspensions of Government contracts have sharply affected the position. Firms that have lost their contracts and have been searching for new work do not find it easy to obtain. The foundries, however, in the aggregate are consuming large tonnages of special refined and low-phosphorus pig iron, and the production of these qualities has been considerably increased. High-phosphorus pig iron is in ample supply and consumers' requirements are easily met. The light castings foundries, which normally consume big tonnages of this class of iron, have been under-employed throughout the war and in all probability will remain in that condition until building activity is resumed at the end of hostilities. Although the hematite position remains tight, production has been improved during recent weeks. The increase in output, however, has not been sufficient to enable the producers fully to meet the demand and consumers are eagerly taking up any parcels which may be allocated to them. The Control, however, takes great care in distributing hematite pig iron, and, wherever possible, consumers are instructed to use some other quality. If the consumers' requirements are urgent and no other description of pig iron will answer the same purpose, the Control sees that the consumers' needs are satisfied. It would appear, however, that the demand for hematite is considerably in excess of the production. There is a large volume of business passing in basic pig iron and the production of this quality is maintained at a high level. The steel works, therefore, appear to be obtaining all the basic pig iron they require.

Scotland and the North

Although a falling-off in new business has been noticeable in the Scottish iron and steel trades, production has been maintained at a high rate; in fact, it has exceeded the specifications for steel material coming forward. The general view, however, is that this will prove a temporary phase in the position of the iron and steel industry and that when the allocations are given out for the next period the activity to which the trade has become accustomed during the war period will return and that extremely busy conditions are likely to be the feature of the position during the first period of the New Year. The works' order books, however, are still congested and in many cases they are committed to deliveries to June, 1944. The decline in the volume of new business is not so noticeable in the re-rolling industry, but even here there are firms who are in a position to accept fresh business. In any case, however, the industry, including steel works and re-rollers, has enough work in hand to keep it fully employed until well into 1944. The end of the year finds the raw materials position satisfactory, with the exception of the heavy and better classes of steel scrap. In some districts steel makers say that their demand for steel scrap is barely satisfied and that they are receiving an increasing proportion of light and inferior descriptions. The volume of business in plates has not appreciably declined. The shipyards continue to be the largest consumers, but considerable quantities are passing to locomotive builders, heavy engineers, power plant makers, and marine engineers. The department which is perhaps the quietest for the time being is that producing sections, but there are no lack of orders for the small sizes. It is in the case of heavy joists and sections that quiet trading conditions prevail. Re-rolling firms in particular have a large volume of orders in hand for light sections. A substantial tonnage of orders is held by the works in the Lancashire area. These include contracts for practically all descriptions of finished steel, with the exception of heavy joists and sections, which are in poor demand. Fresh business in Lancashire, which has been affected by changes in the Government war programme, has revived of late and new orders are coming forward on a heavy scale. It is noticeable, however, that in some departments there is a tendency for producers to offer reasonably early delivery dates. The steel works on the North-West Coast are maintaining a high rate of production. Recently the deliveries have increased in volume, as there has been a great effort to complete contracts before the end of the fourth period.

The North-East Coast and Yorkshire

The volume of business in iron and steel has noticeably declined during the past few weeks. This, however, is a natural movement and largely owing to the approach of the Christmas holidays. On the one hand, the works are in full operation and working off as many contracts due for delivery in the fourth period of the year as possible and are therefore reluctant to accept fresh business, except for forward delivery, and, on the other hand, even those consumers who are experiencing a lull in demand are not anxious to place orders until after the holidays. The year is closing on an entirely different note from that which characterised the market at the beginning of 1943. Except in a few departments, the demand has fallen off recently, and some profess to see indications of the decline spreading to other sections of the iron and steel trade. It seems probable that a fairly substantial tonnage of orders will be carried over into the New Year, and many steel makers have a heavy weight of work in hand for delivery over the first six months of 1944. This is the case in the plate department, and here no recession in consumers' requirements can be seen. The shipyards and the heavy engineering industry are the largest consumers and their requirements have been fully maintained. The demand for plates is still sufficient to tax the resources of the works, although lately there has been some increase in production. The sheet industry also is fully employed and, besides producing a large quantity of thin plates, there is enough work in hand from Government Departments to maintain full operations for several months. The situation in the structural steel department has not altered for some little time. The demand is principally for light sections and a comparatively small business is passing in heavy joists and sections. The alloy steel position seems comfortable and the demand, particularly for engineering qualities, is steady. The approach of the Christmas holidays has had little influence upon the Yorkshire iron and steel industry. The holidays this year will be restricted, although in some cases the necessity of overhauling and repairing plant may lead to a longer break than is likely at the majority of the works. There is a heavy business passing in basic steel and the producing works are fully engaged. The supply of raw materials is satisfactory and this branch of the industry looks as though it were entering upon a long run of great activity.

The Midlands and South Wales

For a few weeks there has been a tendency in the Midlands for the volume of new business in iron and steel to shrink, and the approach of the end of the year appears to have accentuated this movement. There has not been any material change, however, in the demand for plates. The shipyards continue to take large tonnages, whilst heavy engineers, armament manufacturers, and locomotive builders are large consumers. There is also a strong demand from the shipyards for light sections, although the heavy sizes are in poor request. The re-rolling industry in the Midlands is fully employed and has important orders in hand for small steel bars, light sections, and strip, and is likely to be fully employed for a long period. Supplies of billets to the re-rollers have been well maintained, and these works are now receiving regular deliveries. Much of the work they have in hand is for essential purposes. Although the amount of work on the books and the orders coming forward are sufficient to ensure active operations at the re-rolling works, the amount of new business is not so heavy as was the case a few weeks ago. Considerable quantities of sheets are taken up by the shipyards and the pressure upon the sheet makers appears to be increasing, and some consumers are pressing for accelerated delivery. Sheets of special finish are in strong request and buyers with orders to place find it difficult to obtain delivery before Period II of next year. The market for special steels has become more active of late and the makers of cold-rolled strip, bright steel bars, stainless steel, and corrosion-resisting steel are working under strong pressure. The Midland engineering industry is practically fully employed in all branches, excepting that some structural engineers would be glad to obtain more work. In South Wales the pressure of new business appears to have relaxed somewhat, but the iron and steel industry there has a big volume of business in hand and is assured of full operation for a long time. Production is maintained at a high level. Some slackening has been noticed in the demand for billets, but, although the production has been increased, consumers' requirements are sufficient to absorb the whole output. There is also a strong request for sheet and tinplate bars and consumers are taking all the steel allocated to them. The tinplate trade is suffering from war-time restructions.

Iron and Steel Scrap

There has been no relaxation in the pressure from the steel works to obtain heavy steel scrap, and the foundries are also taking up all the cast iron scrap they are able to obtain. It is understood that the instructions to merchants to increase their deliveries of scrap to the steel works by 10 per cent. to the end of the year have been followed, and merchants are making great efforts to maintain these recently improved deliveries. Medium and light qualities of scrap are plentiful and the demand has improved somewhat, as the steel works are unable to obtain all the better-quality scrap they require and have to take some of the former to maintain their production. Some of the stocks of good heavy mild steel scrap cut to furnace and foundry sizes have been considerably reduced, and consumers are eagerly seeking this quality. There is also an active market for bundled steel scrap and hydraulically compressed steel shearings, which are being used in greater quantities owing to the short supply of the heavy material. The production of mild steel turnings seems to have declined, and as this kind of scrap has become less plentiful the demand has improved. Recently there has been a more active demand than for some time for mixed wrought iron and steel scrap for basic steel furnaces. Consumers' requirements of good heavy material are considerable and there is a pressing demand, as supplies appear to be growing less. Plenty of light material is available and fair quantities are passing into consumption. Recently there has been more activity in the demand for basic bundles and quite a good trade has developed. Ironfounders generally are ready to take up good quantities of cast iron scrap, but recently there have been some complaints of the quality of the material available.

Notes and Memoranda

Rail and Road

RAILWAY EXTENSION IN COLOMBIA.—Plans have now been announced in Colombia for the extension of the Troncal de Occidente Railway from Anza (Department of Antioquia) to the city of Antioquia. The completion of this section of railway will open up a rich agricultural area west and north-west of Medellin.

L.M.S. MOTOR TRANSPORT ECONOMY.—Although L.M.S. road motor vehicles moved two million more tons of goods this year than in 1939, the company reduced its mileage by no less than nine million motor miles. This has been achieved principally by careful reorganisation of the company's collection and delivery services.

"TWENTIETH CENTURY" BOILER EXPLOSION.—In a "Seven-Day Journal" note on September 10th we recorded the derailment, in the early morning of September 7th, of the American "Twentieth Century Limited" express at a point 24 miles east of Syracuse. It has now been established that the derailment was caused by the bursting of the boiler of the locomotive—a streamlined 4 6–4. The engine, tender, and eleven vehicles left the track.

L.P.T.B. INTER-STATION BUSES.—On December 20th, a new bus route was put into operation between five principal London main line stations for the convenience of passengers who are unable to obtain a taxi to take them from one terminus to another. This service, which has been arranged at the request of the Ministry of War Transport, is provided daily from 6.30 p.m. until midnight, and the buses run non-stop in both directions at half-hourly intervals between Paddington, Victoria, Waterloo, Euston, and King's Cross.

AMERICAN ROAD WORK.—The new paved highway which has been under construction for the past two years, connecting Montgomery and Tuscaloosa, Alabama, was recently opened to traffic. The road is 99 miles long and saves 43 miles over the old route by way of Uniontown. It has also been announced that Highway 5, a short route between Birmingham and Mobile *vid* Centerville, Marion, Browns, Stafford, Catherine, Grove Hill, and Jackson has been thrown open to traffic. This route cuts out considerable mileage between Birmingham and Mobile.

AMERICAN FIRE-FIGHTING CARS.—The Baltimore and Ohio Railroad, which handles a great deal of oil and other combustible war materials over its lines, has recently converted twelve standard bogie box wagons into fire-fighting cars for use in case of emergency. *Railway Gazette* states that each car is equipped with pumps, a generator, and hose sufficient to reach 400ft. from the car. Tanks of foam, producing about 33,000 gallons of liquid, are stored in each car, and are sufficient for one hour's continuous operation. The foamite is mixed with water from the tender of the locomotive hauling the fire-fighting train, and the locomotive steam is also used to operate the generator and the pumping system. These cars are stationed at twelve depôts in Philadelphia, Maryland, Indiana, and Ohio, which also house breakdown trains.

Miscellanea

INTERNATIONAL RUBBER COMMITTEE.—The International Rubber Regulation agreement, which should expire to-day, December 31st, has been extended for a period of four months. The three signatory Governments still available—the United Kingdom, the Netherlands, and India—are agreed in desiring international co-operation in matters affecting rubber and the retention of machinery for consultation on possible future international action to deal with the post-war problems of the industry. They have therefore considered the possibility of constituting a more widely representative committee for consultation and the collection of information, and it is the hope of the three Governments that all other countries with a substantial interest in rubber or rubber substitutes, whether producers or consumers, will join the proposed Committee. It is further hoped that the new Committee will point the way to international action which will secure the long-term interests of rubber producers and consumers in conformity with such principles for international commodity schemes as may be generally accepted after the war.

Personal and Business

MR. A. GORDON has been appointed an additional director of Parkinson and Cowan, Ltd.

SIR SAMUEL STRANG STEEL has been elected a director of the Scottish Power Company, Ltd.

MR. E. J. HUNTER has been appointed manager of the dry docks department of Swan, Hunter and Wigham Richardson, Ltd.

SIR JAMES MILNE, general manager, Great Western Railway, has been re-elected Chairman of the General Managers' Conference.

THE SOUTHERN RAILWAY COMPANY announces that Mr. H. U. Willink, M.P., has resigned from the board on becoming Minister of Health. Mr. H. Brooke, M.P., has been co-opted to fill the vacancy.

THE MINISTER OF WAR TRANSPORT has appointed Mr. E. B. Hugh-Jones, M.C., B.Sc., M. Inst. C.E., Divisional Road Engineer for the Wales and Monmouth Division in place of Major S. Evans, M. Inst. C.E., F.R.I.B.A., who has retired.

MR. J. W. DAVIES, director and general works manager of Ferranti, Ltd., has been elected President, Manchester district, of the Engineering Employers' Association, having served as Vice-President for the past two years, after many years' service as a member of the Executive Committee. Mr. Davies has been a member of the Ferranti organisation for the past forty-four years, being engaged as a tool maker in 1899. Promoted in turn to foreman and departmental works manager, he was appointed general works manager in 1924.

MR. ALAN P. GOOD has resigned from the boards of Court Works, Ltd., Caprotti Valve Gears, Ltd., Associated Locomotive Equipment, Ltd., and Jones Gas Process Company, Ltd. Mr. James Fielding, managing director of Fielding and Platt, Ltd., and Mr. W. M. Good have been appointed additional directors of Heenan and Froude, Ltd. Mr. W. M. Good has been appointed a director and chairman of Caprotti Valve Gears, Ltd., and Associated Locomotive Equipment, Ltd., and a director of Court Works, Ltd., and Jones Gas Process Company, Ltd. Mr. G. M. Gill, managing director of Severn Valley Gas Corporation, Ltd., has been appointed chairman of Jones Gas Process Company, Ltd. Mr. W. M. Ratcliffe, managing director of Heenan and Froude, Ltd., has been appointed chairman of Court Works, Ltd. Mr. James Barclay is resigning from the board of Jones Gas Process Company, Ltd., and Messrs. P. A. A. Gooch and C. E. New from the boards of Caprotti Valve Gears, Ltd., and Associated Locomotive Equipment, Ltd.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Jan. 10th.—Technical College, Bradford. "Gears and their Application," W. A. Tuplin. 6.45 p.m.

Engineer Surveyors' Association

Friday, Jan. 7th.—Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow. "Electric Welding and Equipment," G. C. Sutherland. 7 p.m.

Institute of Fuel

Thursday, Jan. 6th.—Inst. of Mechanical Engineers, Storey's Gate, S.W.1. "The Heat Content of the Products of Combustion," E. L. Luly. 2.30 p.m.

Wednesday, Jan. 12th.—Engineers' Club, Albert Square, Manchester. Address by E. S. Grumell. 2.30 p.m.

Thursday, Jan. 13th.—Chemical Dept. of the University, Woodland Road, Bristol. "Post-War Coal Processing," G. M. Gill and J. Roberts. 5.30 p.m.

Friday, Jan. 14th.—Chamber of Commerce, Swansea. "The Production of Producer Gas and Blue Water Gas," H. R. Forman. 4 p.m.

Institution of Automobile Engineers

Sunday, Jan. 9th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. Address by G. H. Lanchester. 3 p.m.

Institution of Chemical Engineers

Tuesday, Jan. 11th.—Geological Society, Burlington House, Piccadilly, W.1. "The Manufacture of Margarine," A. J. Andersen. 2.30 p.m.

Institution of Electrical Engineers

Wednesday, Jan. 12th.—SCOTTISH CENTRE: Heriot-Watt College, Edinburgh. "The Future of Domestic Wiring Installations," F. Jackson, W. J. H. Wood, G. Smith, and E. Jacobi. 6 p.m.

Institution of Mechanical Engineers

To-day, Dec. 31st.—Storey's Gate, Westminster, S.W.1. "Paints and Protective Finishes for Metals," A. J. Philpot. 5.30 p.m.

Tuesday, Jan. 4th.—S. WALES BRANCH: S. Wales Inst. of Engineers, Park Place, Cardiff. "Gyroscopic Principles and Applications," C. E. Inglis. 3 p.m.

Saturday, Jan. 8th.—WESTERN BRANCH: Physics Dept., The University, Royal Fort, Bristol. "Gyroscopic Principles and Applications," C. E. Inglis. 2.30 p.m.

Monday, Jan. 10th.—N.E. BRANCH: Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Naval Machinery: Some Factors Influencing its Design," Eng. Vice-Admiral Sir G. Preece. 6 p.m.

Thursday, Jan. 13th.—SCOTTISH BRANCH: Royal Technical College, Glasgow. "Survey of Plastics from the Viewpoint of the Mechanical Engineer," S. Livingston Smith; and "Moulding Plant for Plastics," J. L. Daniels. 7.30 p.m.

Friday, Jan. 14th.—SOUTHERN BRANCH: Royal Aircraft Establishment, Farnborough. "Gyroscopic Principles and Applications," C. E. Inglis. 7.30 p.m.

Saturday, Jan. 15th.—LONDON GRADUATES: Storey's Gate, Westminster, S.W.1. "Locomotives I Have Known," O. V. S. Bulleid. 3.30 p.m.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester. "Remember the Past and Look to the Future," F. C. Lea. 2.30 p.m.

Institution of Production Engineers

Monday, Jan. 3rd.—COVENTRY GRADUATES: Technical College (Room A5), Coventry. "The Design of Cams for Single-Spindle Automatic Machines," G. A. Bayley; "Waste Elimination and Salvage," D. H. Morgan; and "The Relationship between the Production Engineer and the Management," J. B. Scott. 6.45 p.m.

Friday, Jan. 7th.—Inst. of Civil Engineers, Great George Street, S.W.1. "Training of Young Engineers," W. Hewett. 7 p.m.—LINCOLN SECTION: Robey's Canteen, Canwick Road, Lincoln. Discussion on "Inspection." 6.30 p.m.—MANCHESTER SECTION: Mechanics' Institute, Crewe. "Production Control," R. Appleby. 7.15 p.m.

Saturday, Jan. 8th.—YORKS SECTION: Hotel Metropole, Leeds. "Production Control," R. Appleby. 2.30 p.m.

Iron and Steel Institute

Tuesday, Jan. 11th.—Technical College, The Broadway, Dudley. "A Study of Austenitic Grain Growth in Medium-Carbon Steels," J. H. Whiteley. 7 p.m.

Thursday, Jan. 13th.—Rational Hall, Ebbw Vale. "Research in the Steel Industry," C. H. Desch. 7 p.m.

Junior Institution of Engineers

Friday, Jan. 7th.—39, Victoria Street, S.W.1. "Some Causes of Failure in Medium and High-Duty Helical Compression Springs," G. H. Jackson. 6.15 p.m.

Keighley Association of Engineers

Friday, Jan. 7th.—Victoria Hotel, Keighley. "A Yorkshire Gentleman, Three Centuries Ago," C. Whone. 7.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Jan. 7th.—Mining Institute, Newcastle-upon-Tyne. "The Influence of Production Requirements on the Design of Reciprocating Machinery," R. E. Strub. 6 p.m.

Royal Aeronautical Society

Thursday, Jan. 6th.—GRADUATE SECTION: 4, Hamilton Place, W.1. "Technical Problems in the Conversion of Military Aircraft to Civil Use," G. d'Erlanger. 7.30 p.m.

Wednesday, Jan. 12th.—4, Hamilton Place, Piccadilly, W.1. "The History of the Royal Aeronautical Society," J. L. Pritchard. 7.30 p.m.

Royal Institution

Saturday and Tuesday, Jan. 1st and 4th.—21, Albemarle Street, W.1. "Vibrations and Waves," E. N. da C. Andrade. 2.30 p.m.

Royal Society of Arts

Wednesday, Jan. 12th.—John Adam Street, Adelphi, W.C.2. "The Story of Petroleum," Sir Frank Smith. 2.30 p.m.

Wednesday, Jan. 19th.—John Adam Street, Adelphi, W.C.2. "London's Water Supply," H. Berry. 1.45 p.m.

END OF VOL. CLXXVI

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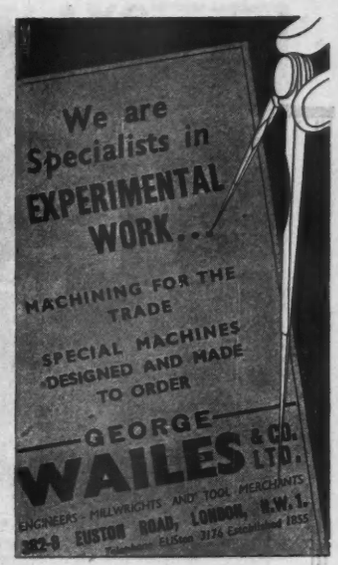
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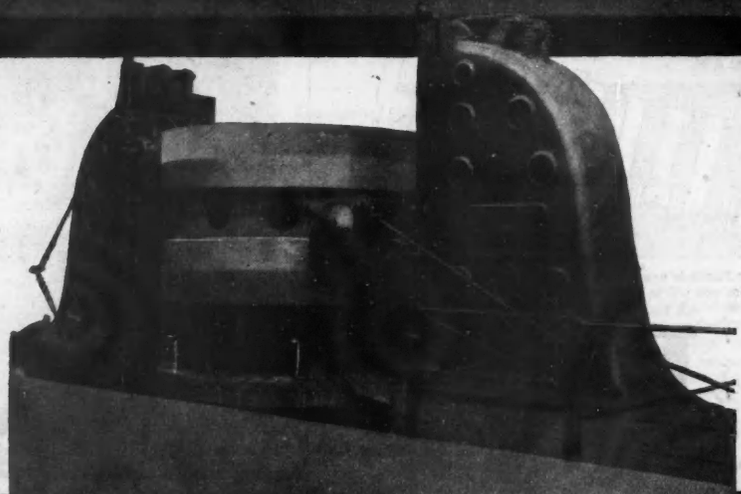

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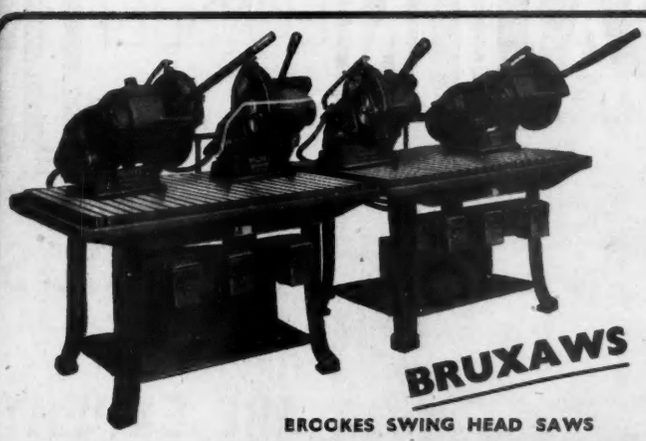

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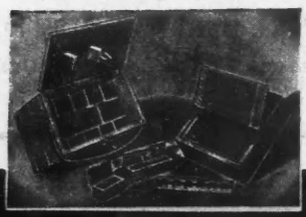

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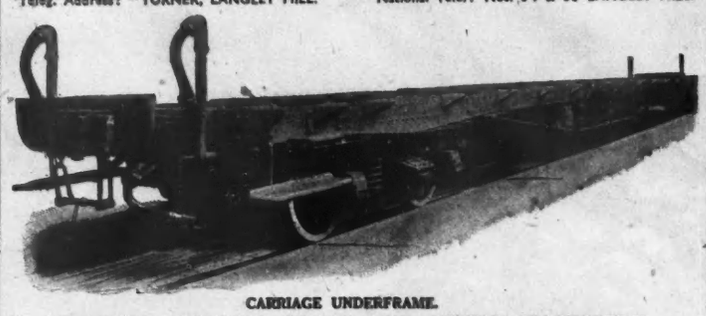

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RAILWAY ROLLING STOCK AND MINING MACHINERY.
London Office—32, Victoria Street, Westminster, S.W.1.

Trade PULSOMETER Mark CENTRIFUGAL
PUMPS
High Efficiency for All Duties
All Heads up to 500 Feet

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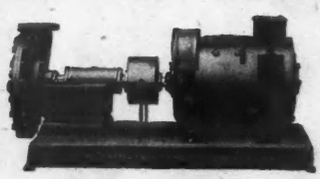

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"Pulsometer" Two-Bearing Pumps have been introduced for use where working conditions require an end suction type of pump for arduous duties and heads up to 180 feet.

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Fit Kolok Positive Lock Washers between every nut and bolt, and so protect your machinery against vibration, the cause of over 50% of its wear and tear. Specify Kolok Positive Lock Washers for Positive Security.
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ENGINEERS & CONTRACTORS,
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Tractors · Locomotive
conserve man power
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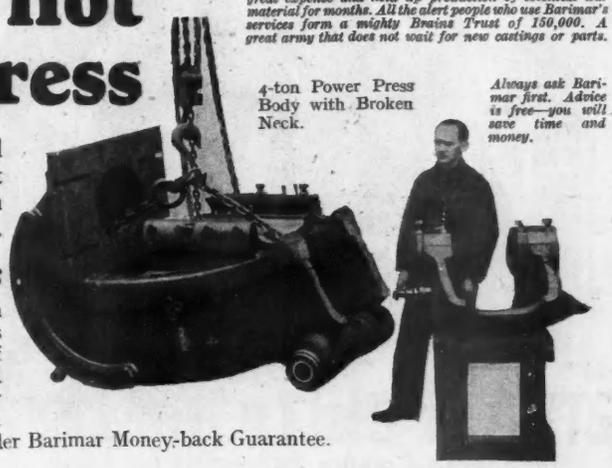
To-day it is only the ignorant who order a new casting at great expense and hold up production of essential war material for months. All the alert people who use Barimar's services form a mighty Brains Trust of 150,000. A great army that does not wait for new castings or parts.



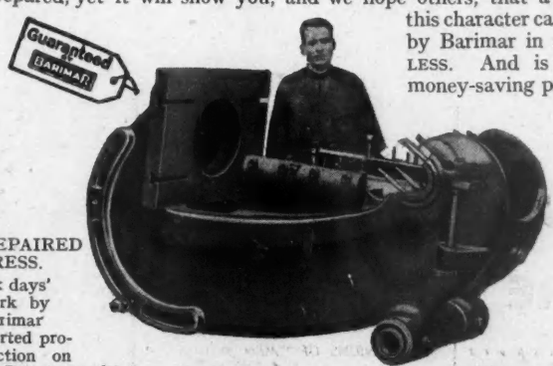
4-ton Power Press Body with Broken Neck.

Always ask Barimar first. Advice is free—you will save time and money.

IF YOU ARE operating machinery of any kind engaged on War production, it is vital for you to know that Barimar stops the leaks in production through broken machines of any kind, any size or made in any metal.

Power Presses are crashing their necks

these days through rush and semi-skilled operation, and while the 4-ton press body illustrated is not the biggest press job that Barimar has prepared, yet it will show you, and we hope others, that a breakage of this character can be repaired by Barimar in SIX DAYS or LESS. And is done at a money-saving price and under Barimar Money-back Guarantee.



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Six days' work by Barimar started production on 1A Priority work at customer's factory.

The neck of the power press is its weakest point, and in this case the broken-off portion weighed several hundredweights. Thick metal has no terrors for Barimar, as special Welding Plants and skilled men set up these jobs to give the utmost strength and to preserve dead alignment throughout the welding operations. You may have heard of glue used in Aircraft construction that is stronger than the wood it unites. Well, Barimar welding is like that. Tests in breaking Barimar welds show an average 25 per cent. gain in strength over the ordinary cast iron used in such castings as machine frames.
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THE WORLD'S SCIENTIFIC WELDERS

Side-Tracked !

Every day thousands of wagons are collected in marshalling yards and sent off north, south, east and west. And each wagon stops at somebody's loading bay or siding.

From every quarter voices are calling out for them.

You must help us to get them together again. When they come to you, free them without one minute's needless delay. We did well last year—thanks to you. This year let's do better, for our growing attack calls for more and more transport. In war time all transport lines lead to the battlefront; every vehicle is on its way to our fighting men. Speed their journeys!

QUICKER TURNROUND THAN EVER BEFORE

Issued by the Ministry of War Transport

You know your own problems best. Tackle them in your own way. But tackle them now. Plan, encourage ideas, improvise if needs be. Here's a starting-off agenda:

1. CLEAR LABELS AND DOCUMENTS.
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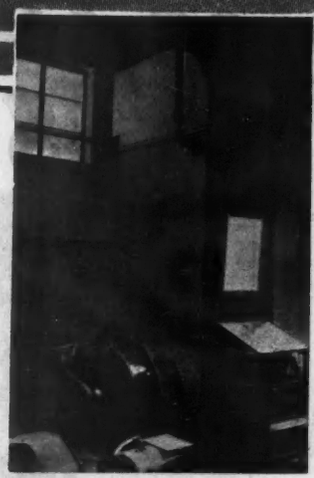

Water Cooling

A Visco Steelshell Force-draft Cooling Unit will save quite 98% of your Water Bill. With this unit the cooling water is used over and over again instead of running to waste. A Visco Cooling Unit is inexpensive to install, economical to run, and takes up very little space—it can be placed inside the plant house if desired. We illustrate a Visco Steelshell Force-draft Cooler of 1,620 gallons per hour capacity. This also serves to ventilate the engine room.

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Suitable for **ENGINEERS, SHIPBUILDERS & REPAIRERS, WATERWORKS CONTRACTORS, RAILWAY CARRIAGE & WAGON WORKS, MUNICIPAL ROADS & TRANSPORT DEPARTMENTS.**

Wells' heating plants are made in eight different sizes, and whatever the work, if portable heat is required, there is a Wells' plant suitable for the job. There are small plants using as little as half a gallon of paraffin per hour to powerful plants giving a flame of 2,150 degrees Fahr. (and consuming 2½ gallons per hour). If portable heat is one of your problems—let Wells solve it for you.

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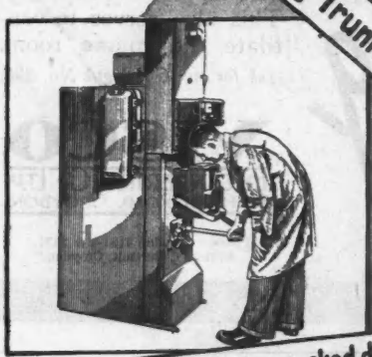
A space saving SWITCH UNIT

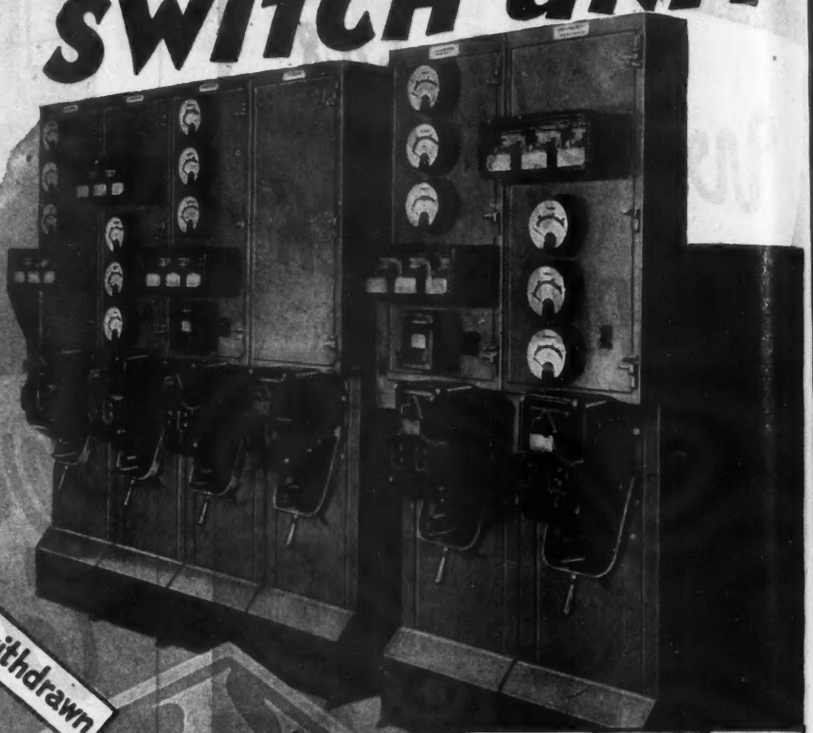
Showing Trunnion blocks withdrawn



Circuit Breaker being racked down for isolation

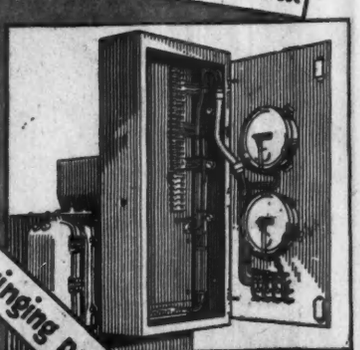
Circuit Breaker Truck withdrawn from cubicle

Circuit Breaker lifted for contact inspection



TYPE VT

Front view showing easy access to cable box



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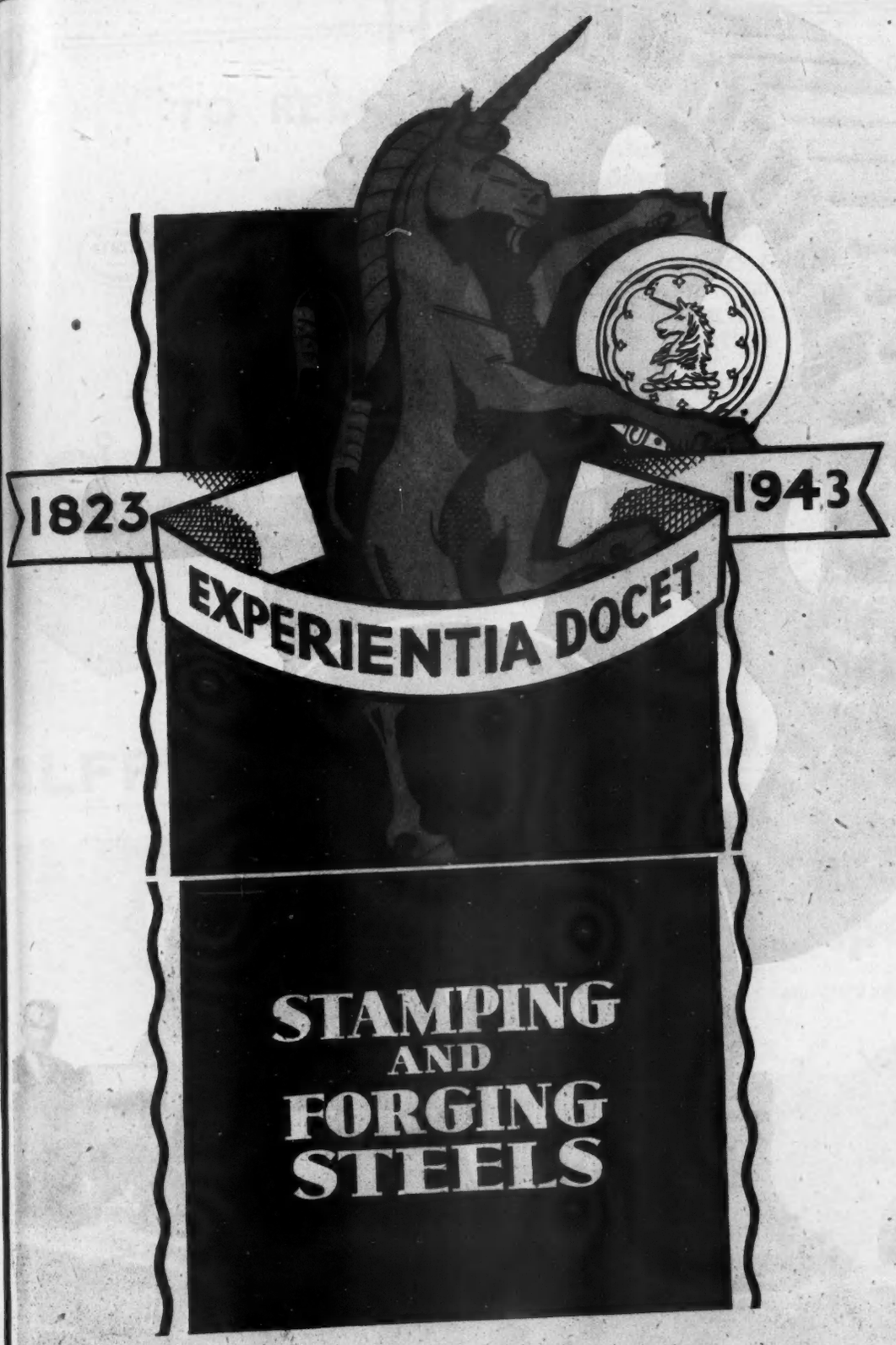
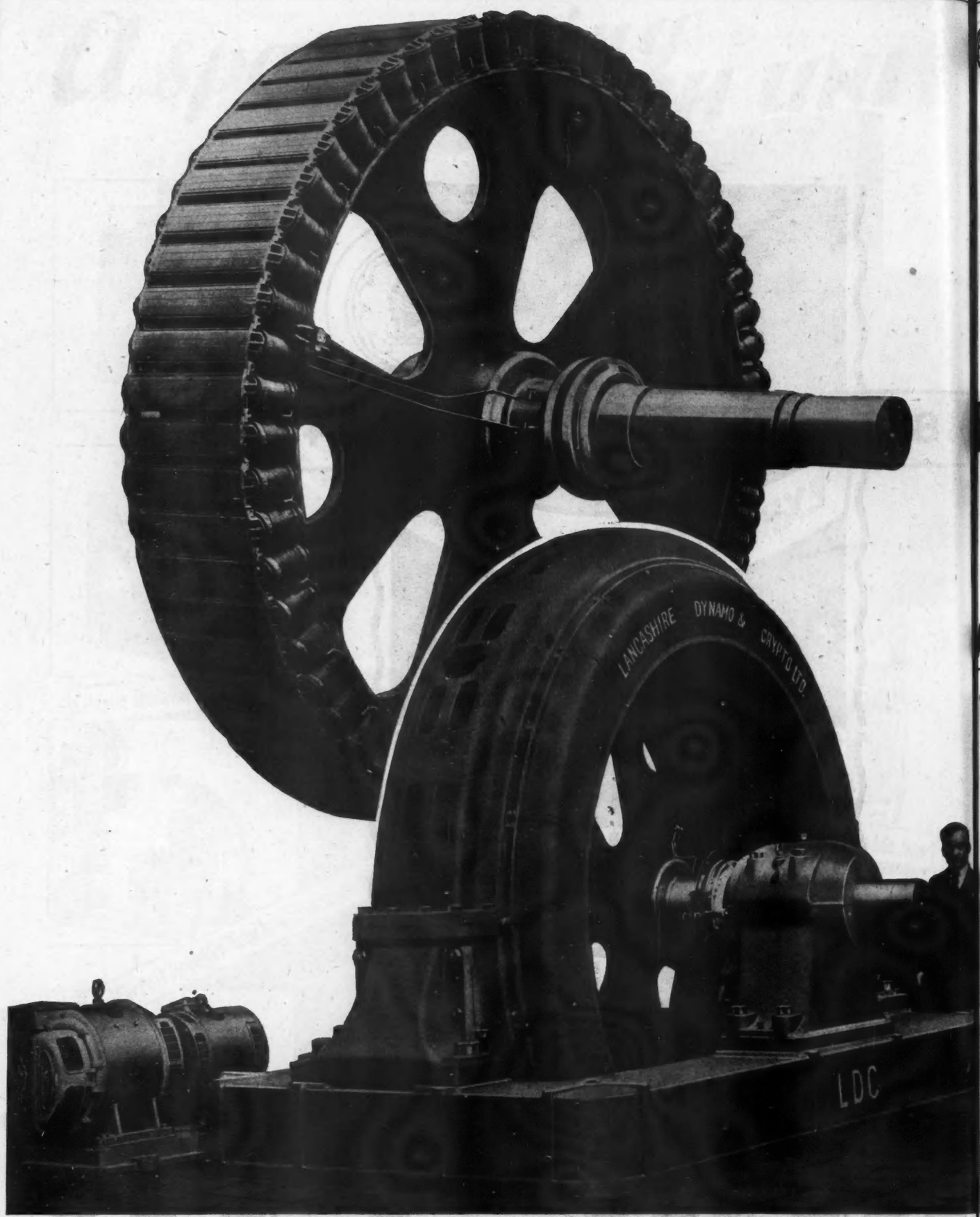


THE
PARK GATE
IRON & STEEL CO LTD
Park Gate Works Rotherham



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No. 6 ...	... 500 lb. per hour	No. 10	2000 lb. per hour
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42in. (1070 mm.) CENTRES

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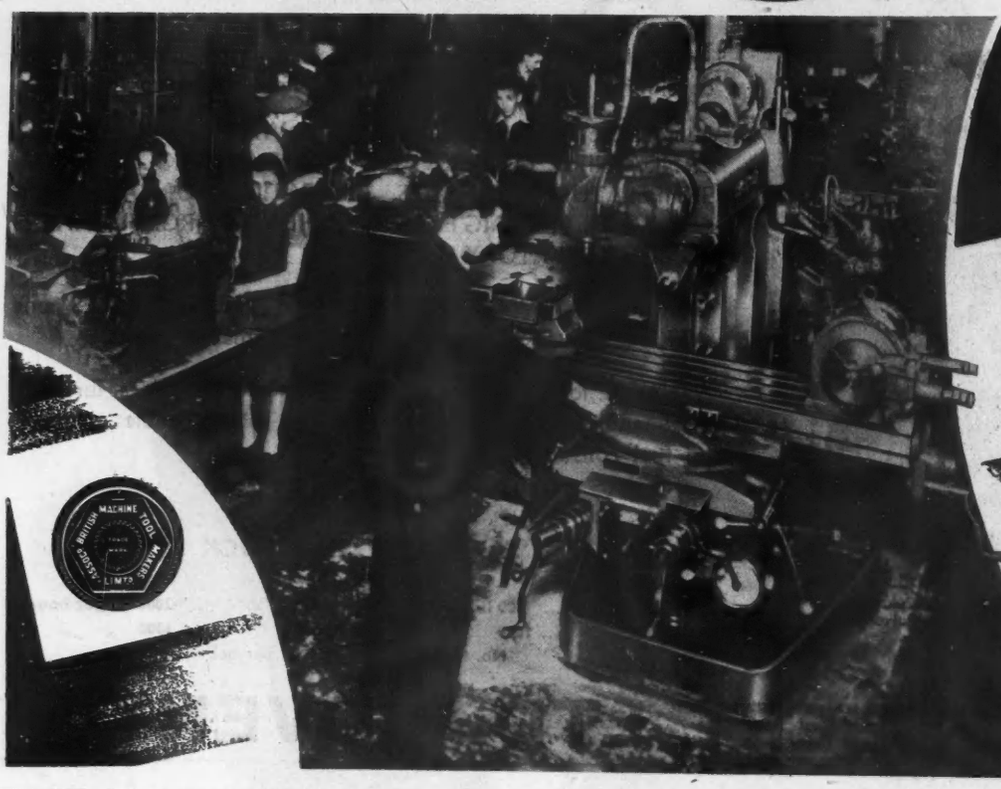

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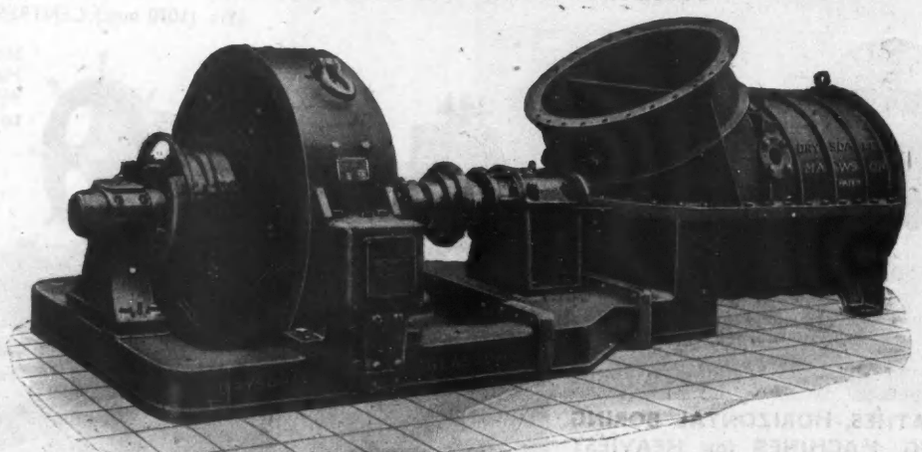

50,000 Gallon per minute Pump supplied to
The County Borough of Blackpool.

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Good watch prevents misfortune

Safety on the road depends on "keeping a good watch"—a constant watch ahead! Misfortune will overtake you sooner or later, maybe sooner, if you allow your attention to be diverted for one moment.

Make the road of production safe and the volume of production sure, by attending to that little amount of simple routine inspection and maintenance of your electrical equipment.

Minor Repairs PREVENT Major Breakdowns

ISSUED BY THE D.I.E.E. IN COLLABORATION WITH BRITISH ELECTRICAL MANUFACTURERS

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HIGGS MOTORS
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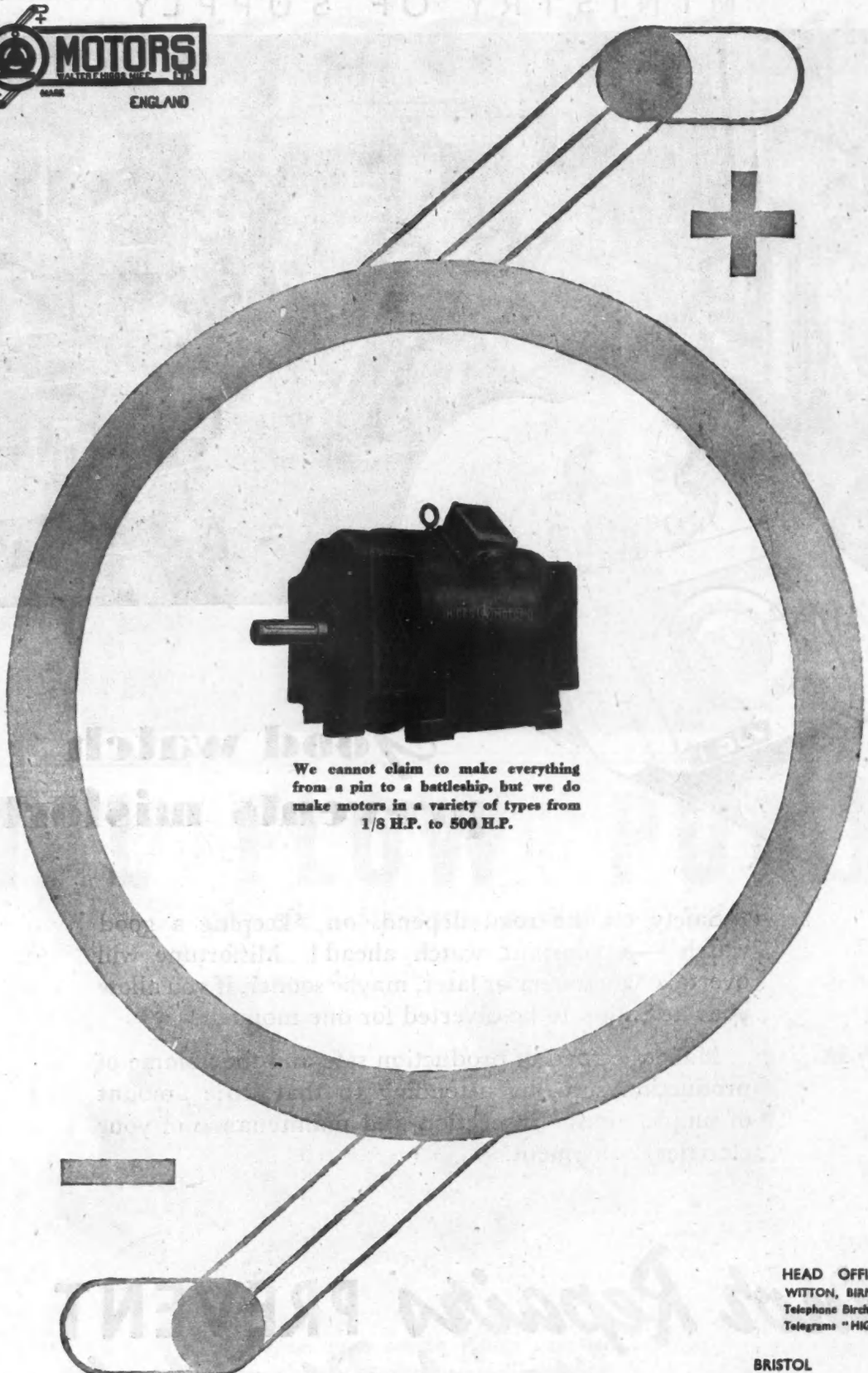

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WE ALSO PRODUCE

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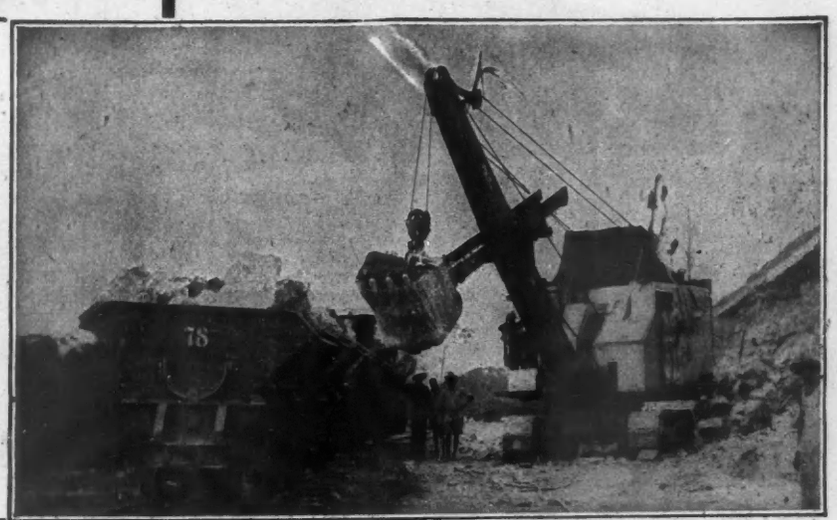

Illustration 1661
SELF-EMPTYING AND Rrighting
LARGE TIP WAGONS AT WORK

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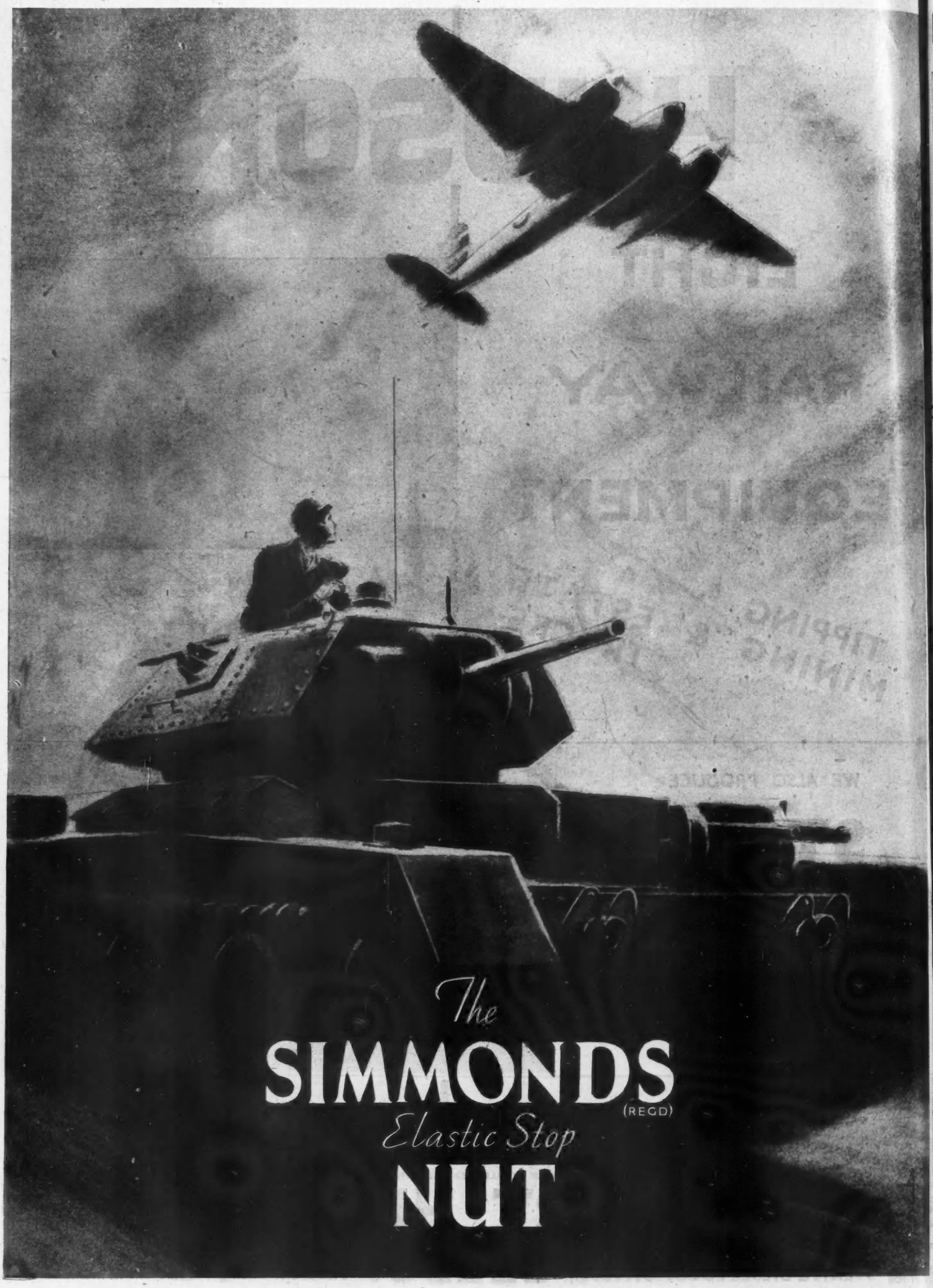
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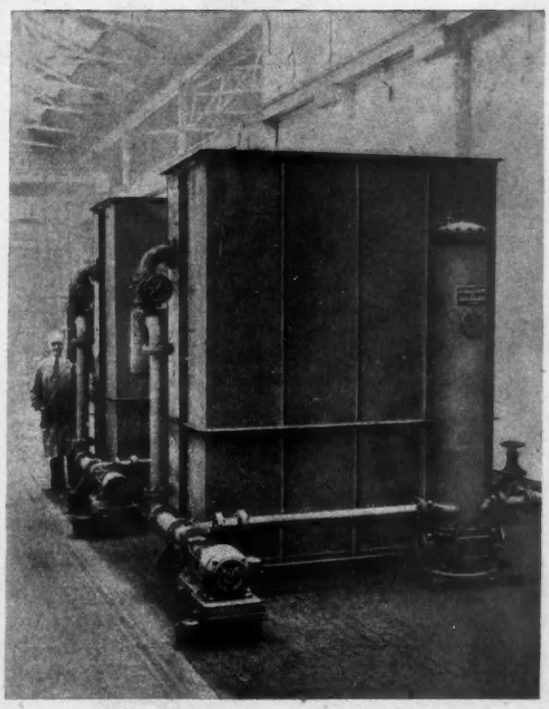

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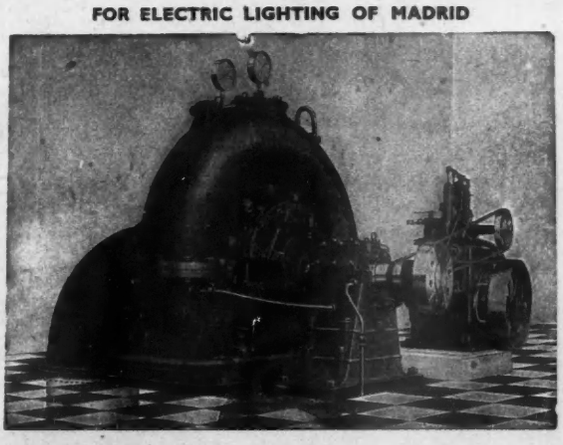

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PATENT MOVING BALL TYPE

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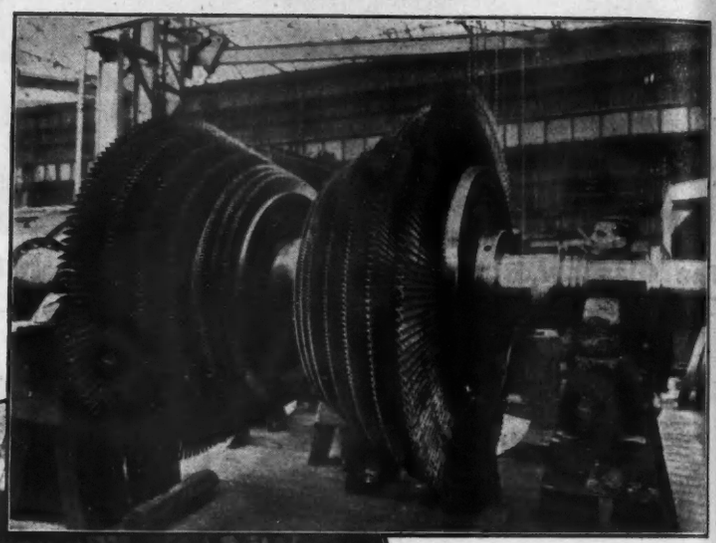

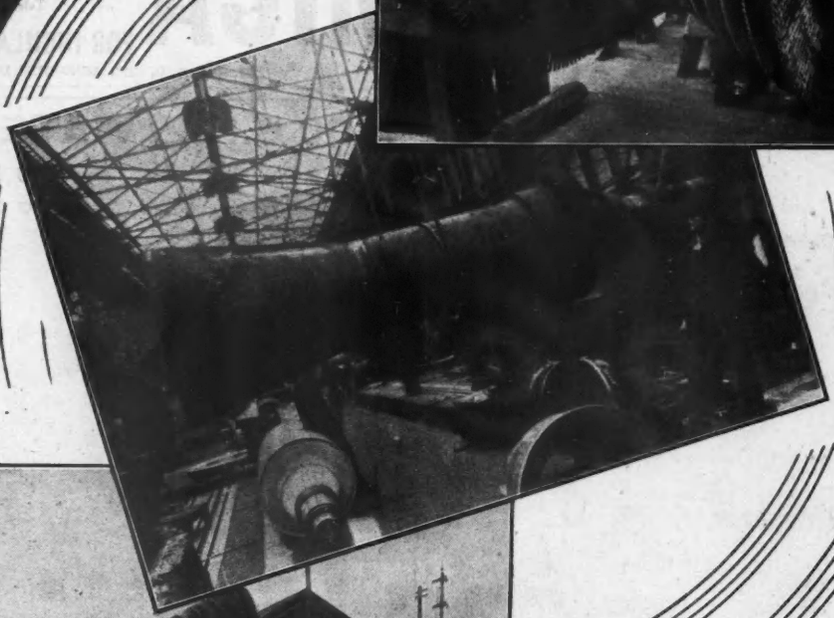

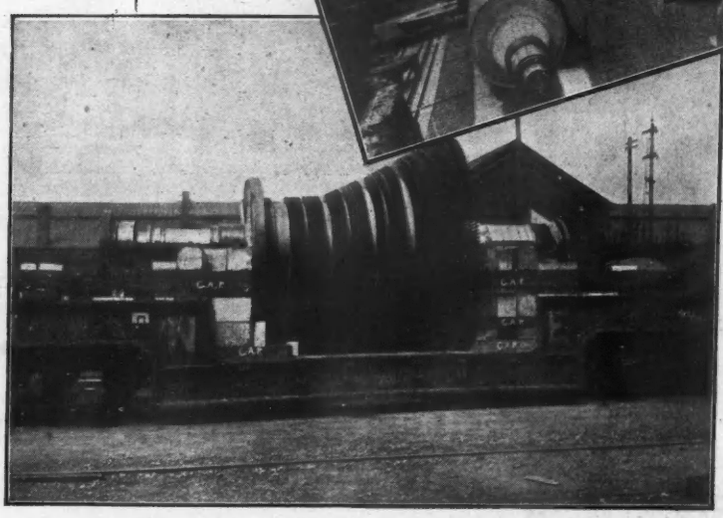

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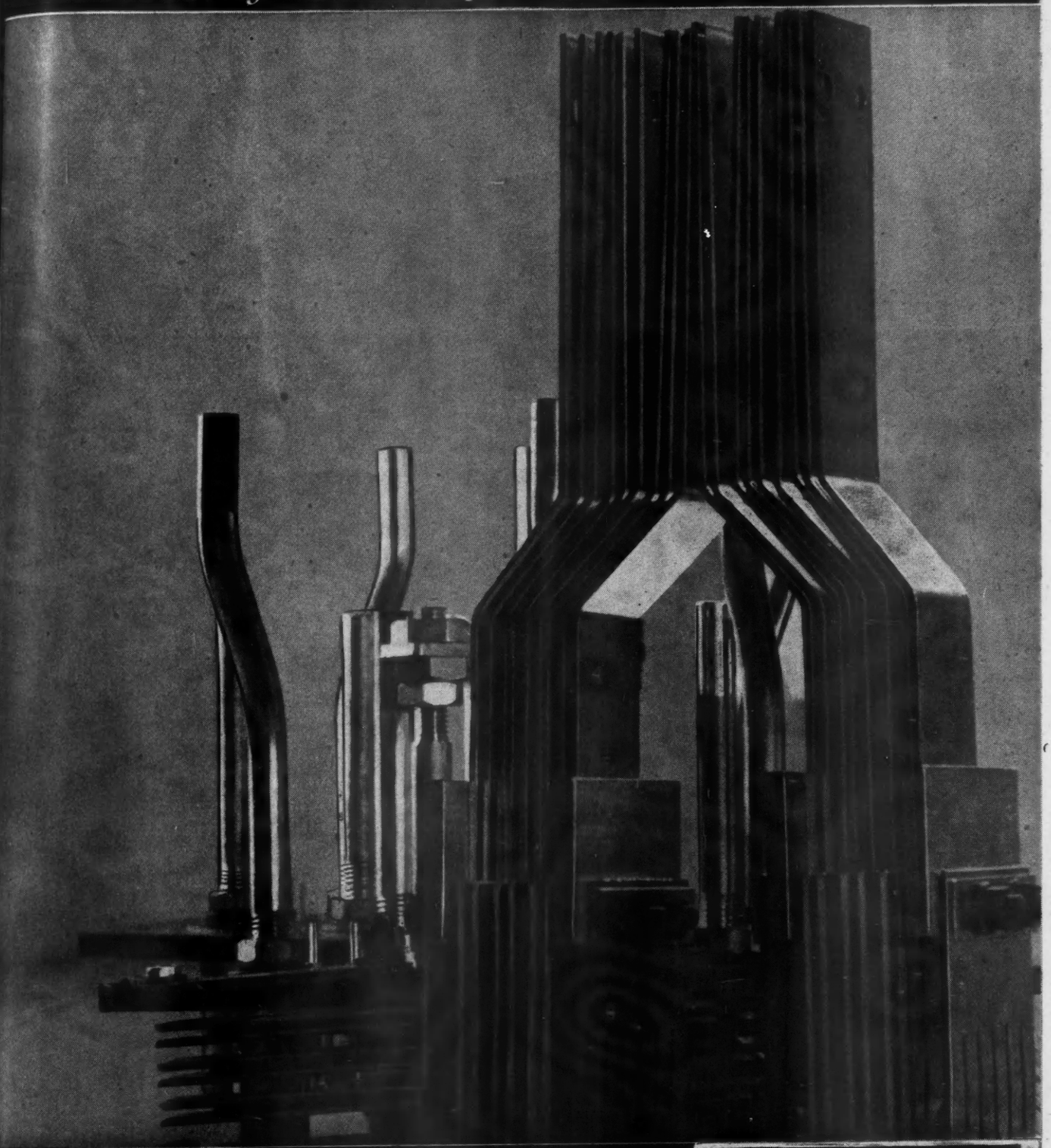
& COMPANY LTD

Newcastle-on-Tyne, 6.

London Offices:
56, Victoria Street, S.W.1.

Pattern of Industry: Documentary of work in progress No. 9



Good materials plus good craftsmanship: Ellison isolator contacts aptly suggest power station cooling towers and the smoke stacks of industry.

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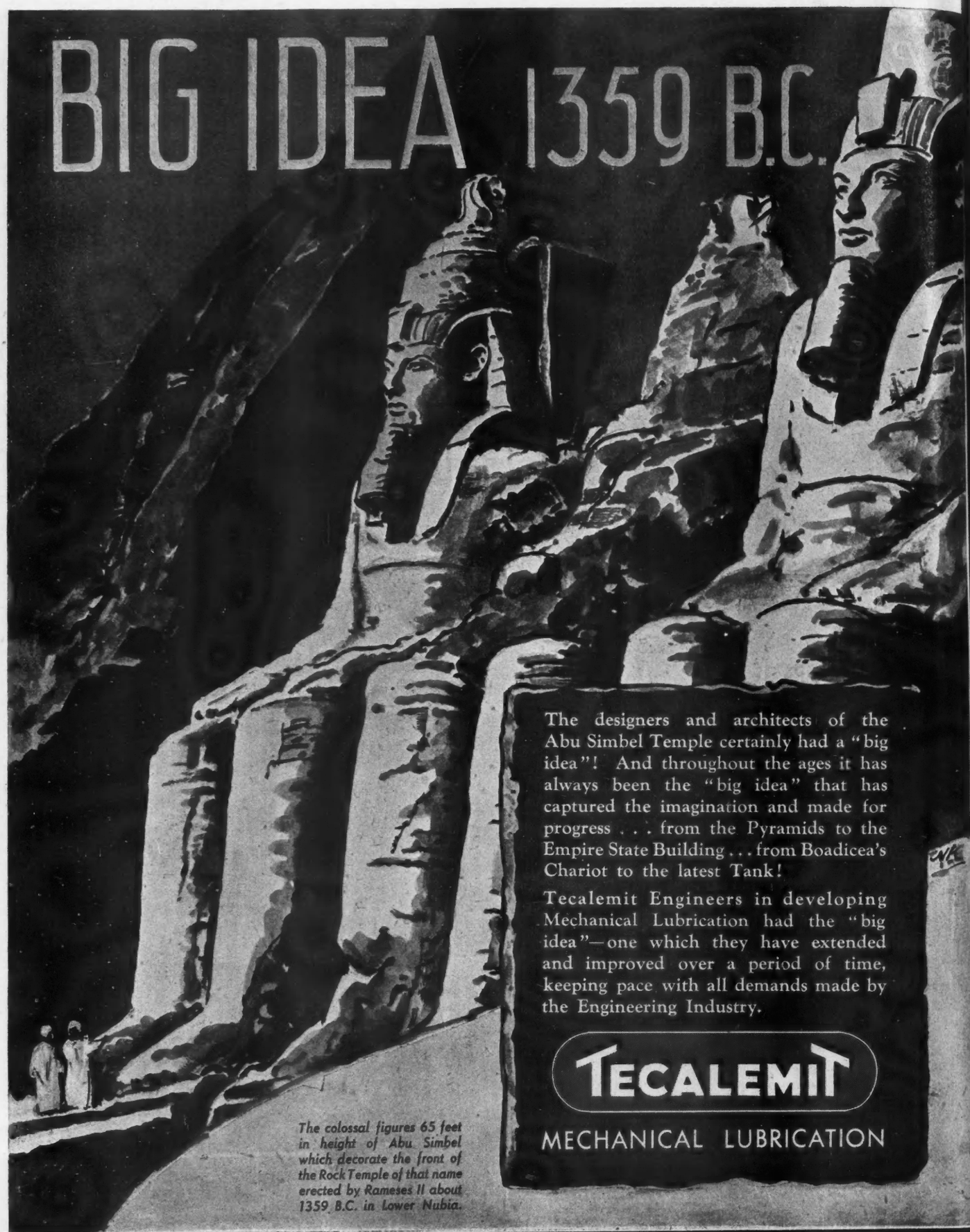
469

BIG IDEA 1359 B.C.



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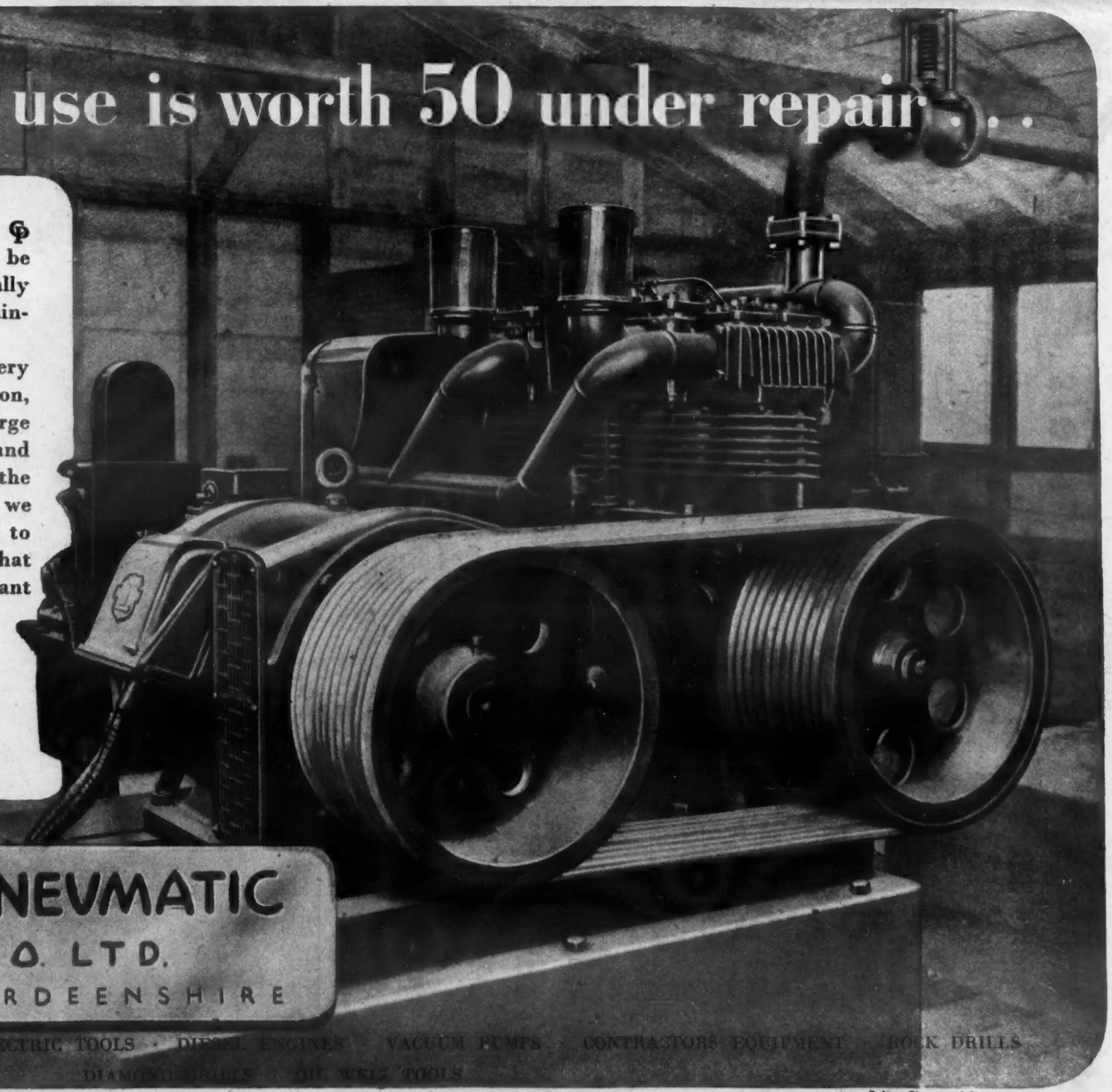

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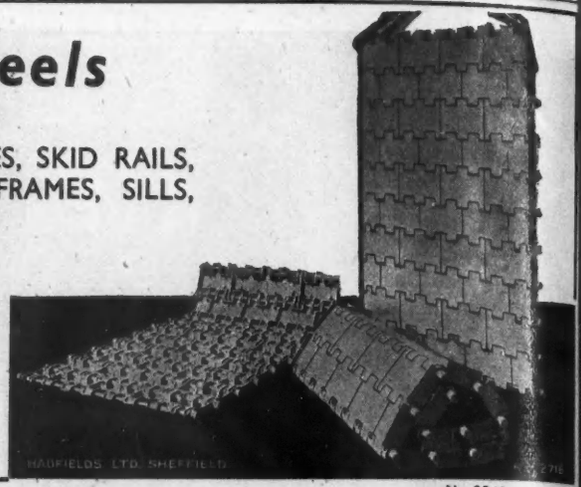

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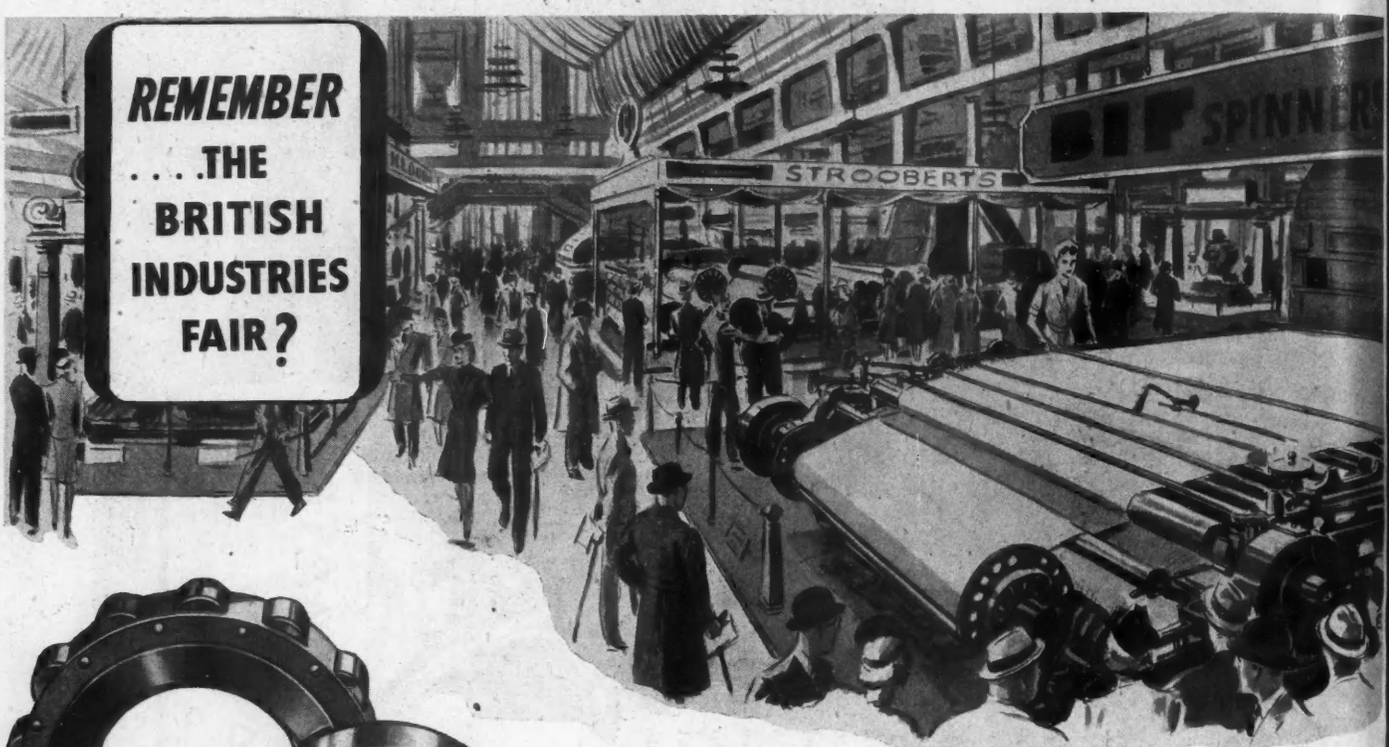

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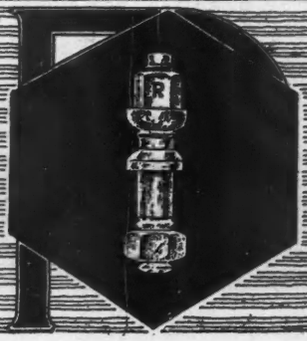

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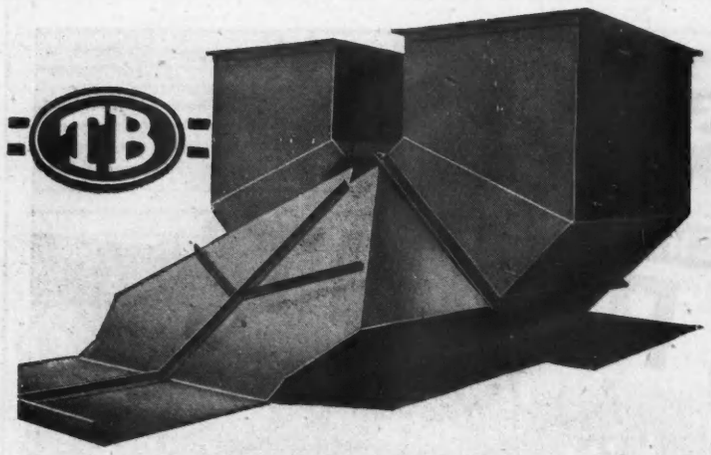

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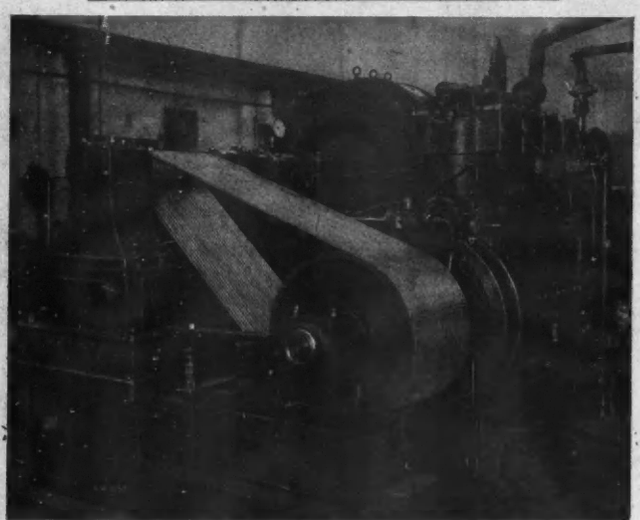

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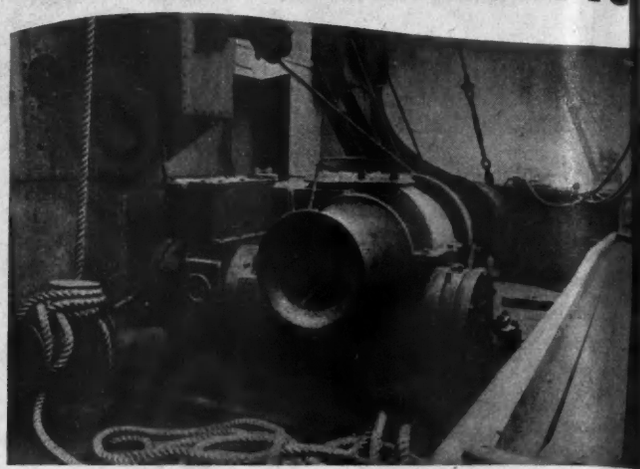
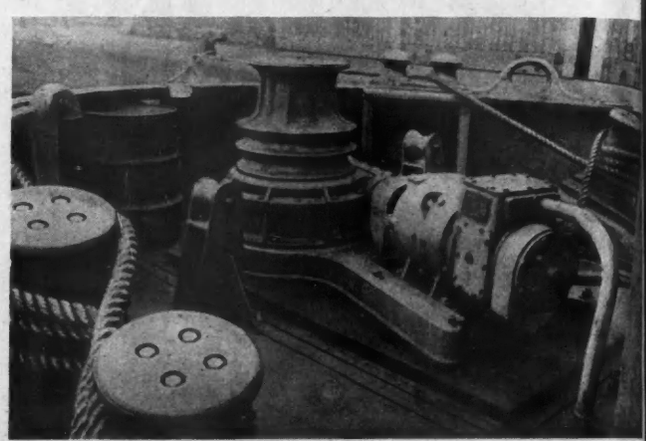


(Above) One of 3 Electrically-driven Worm-geared, Silent-running, Cargo Winches, each lifting 3 tons at 100 feet per minute.

(Below) Electric Worm-geare Aft Capstan with emergenc steering drums. Working pull 3½ tons at 50 feet per minute.



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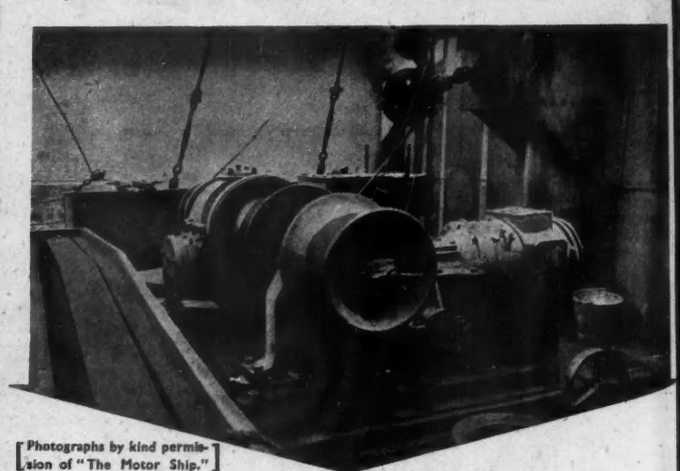

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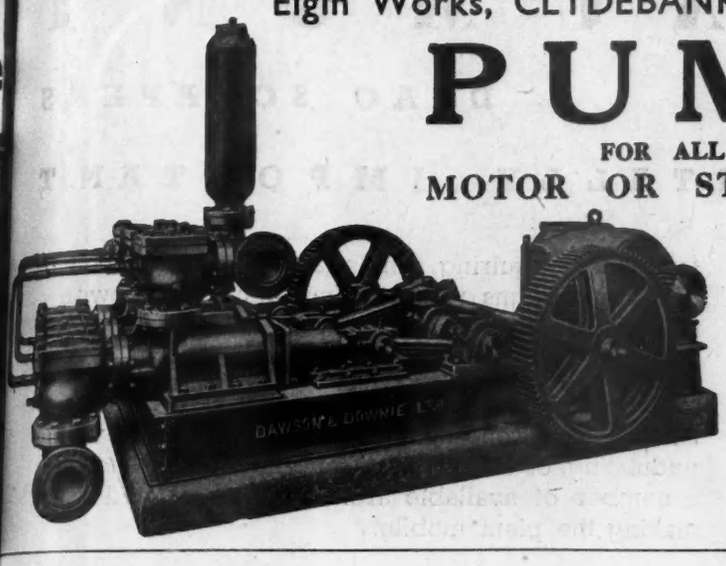

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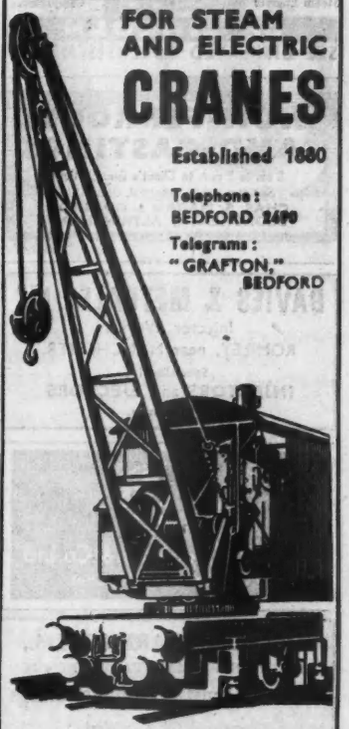

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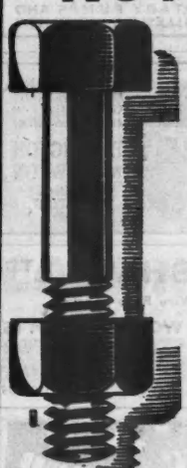

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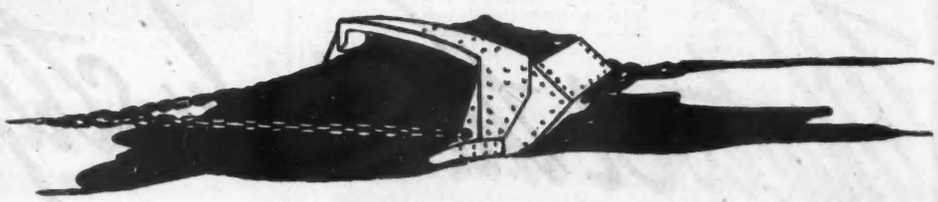

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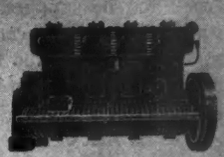

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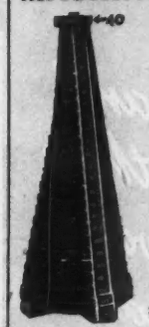

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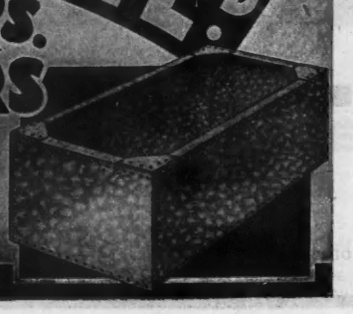

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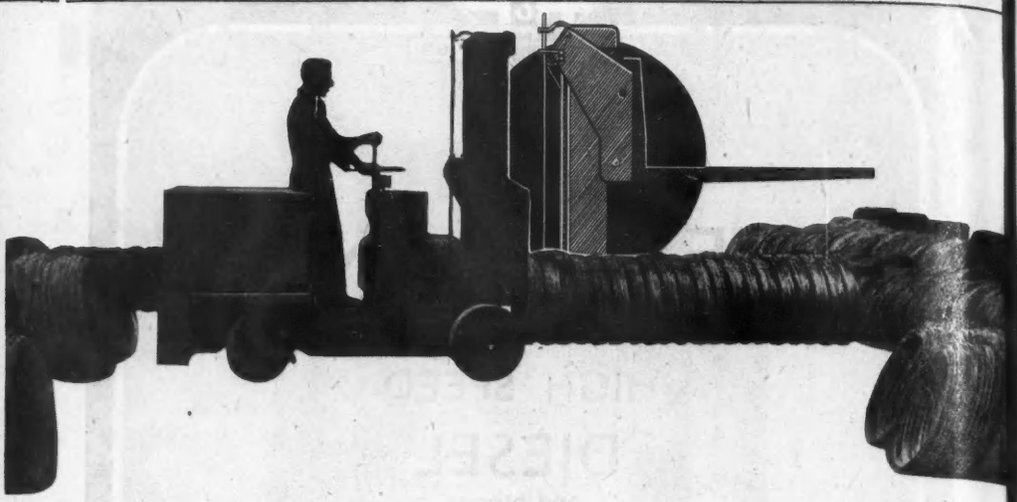

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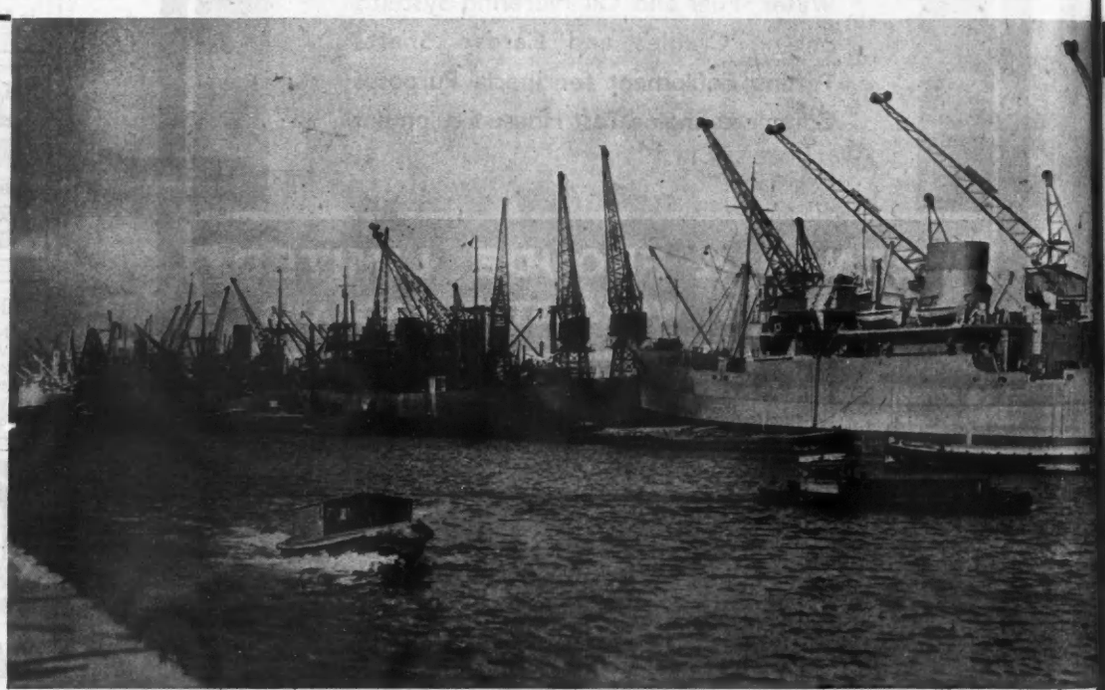

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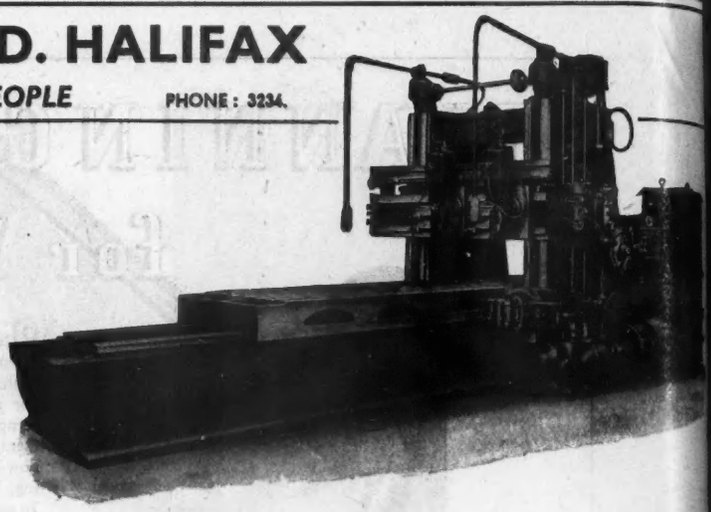

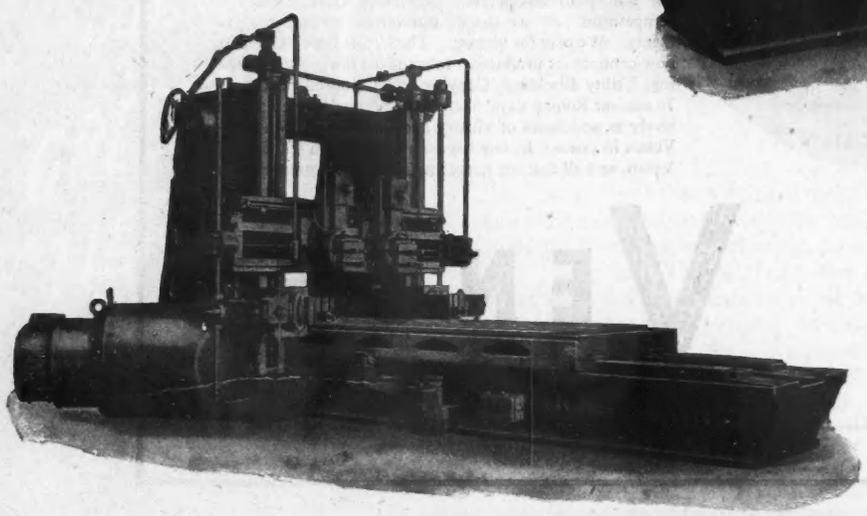

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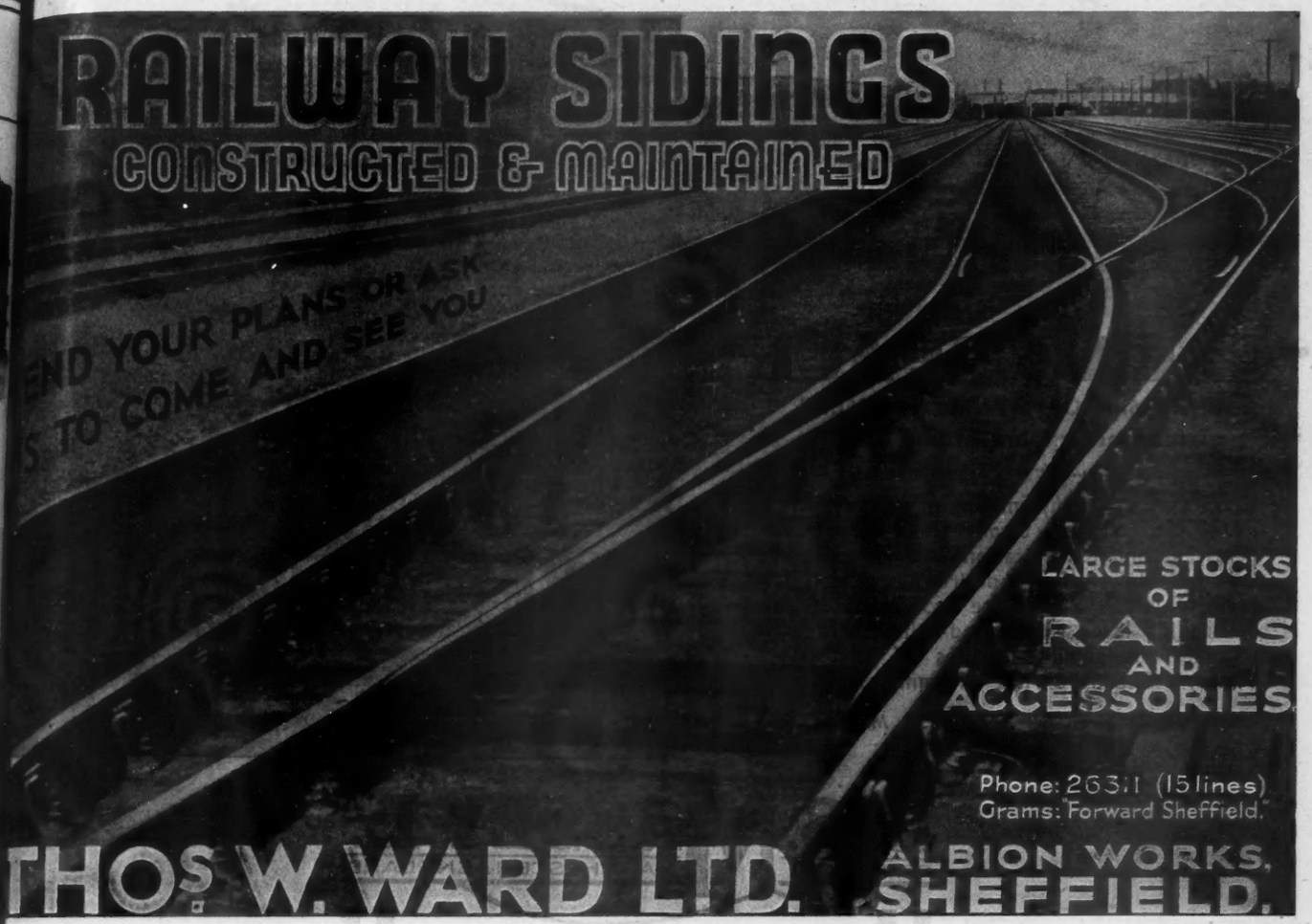

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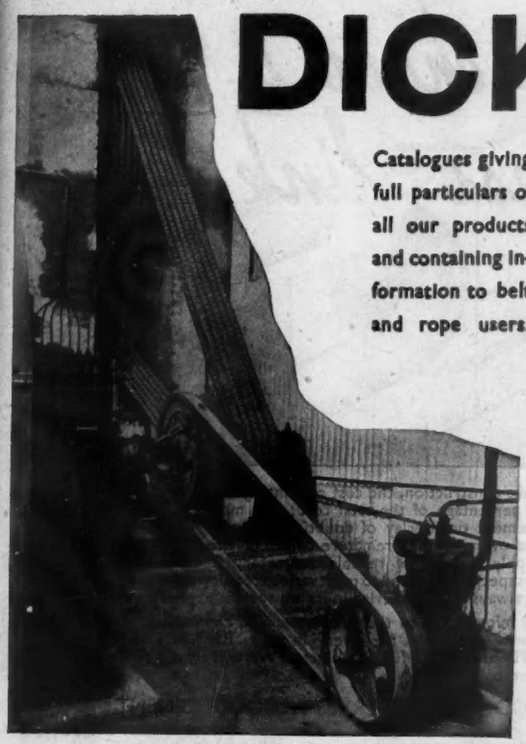

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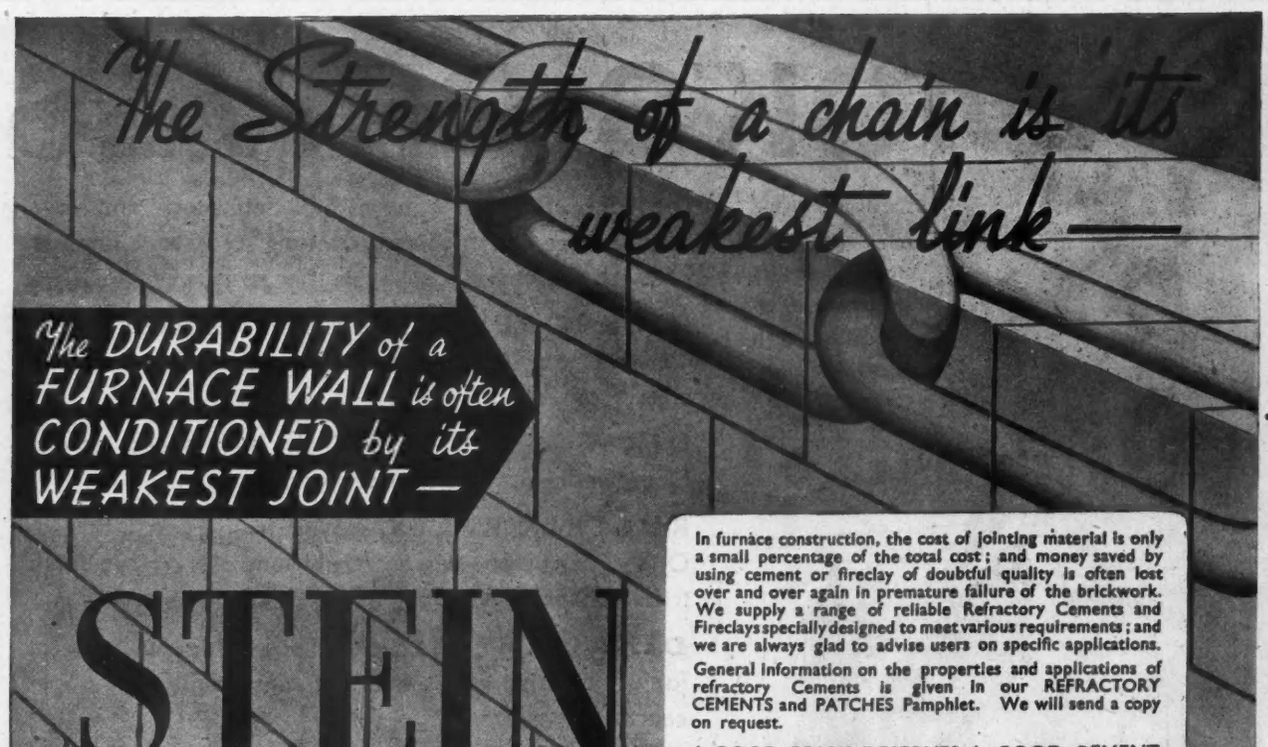
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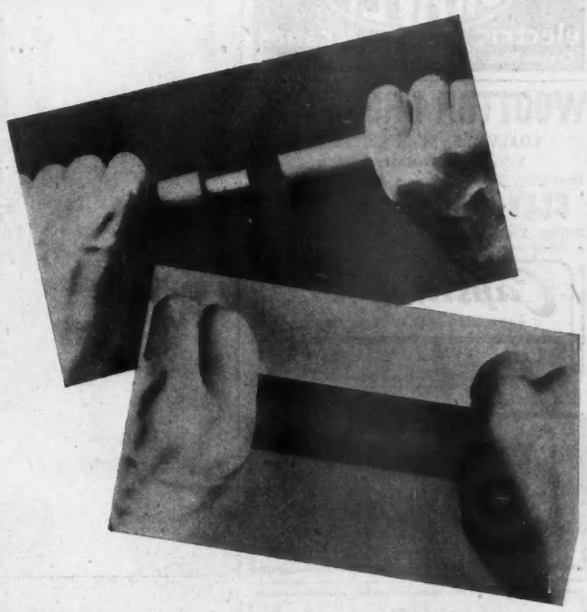

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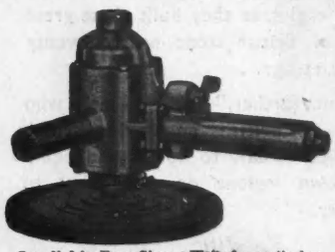

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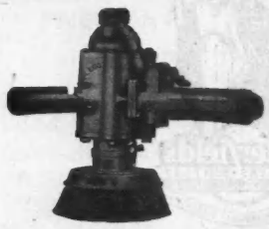

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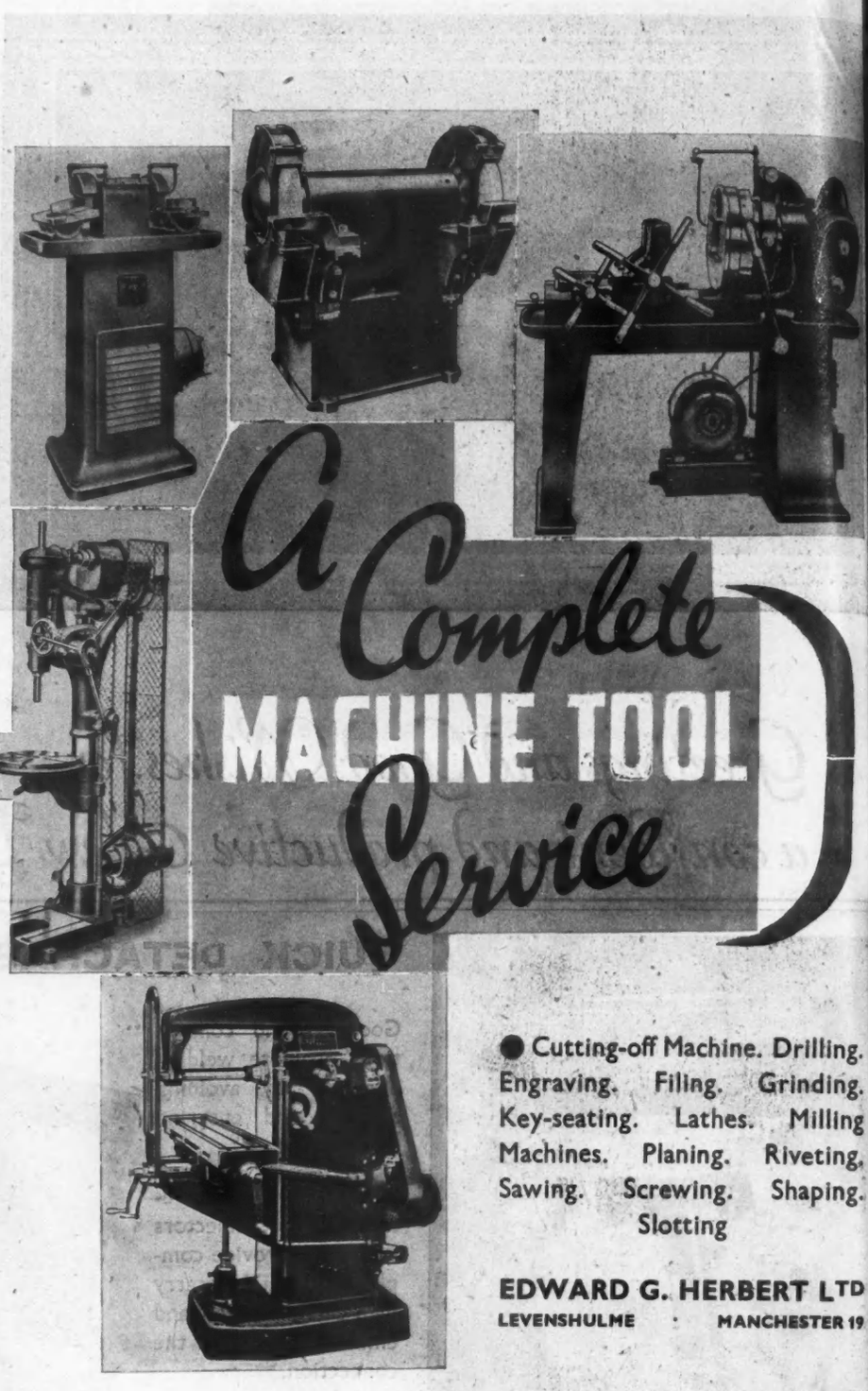

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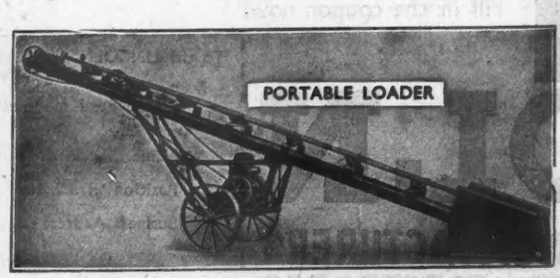

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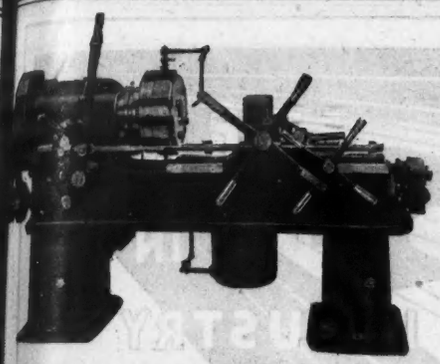

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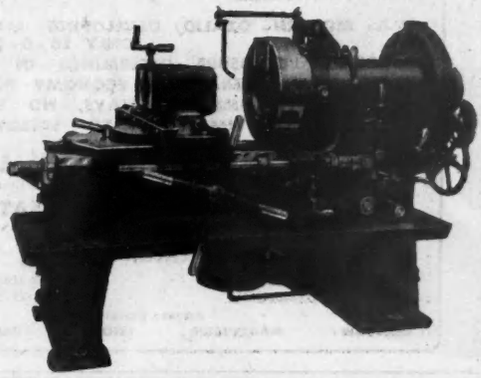

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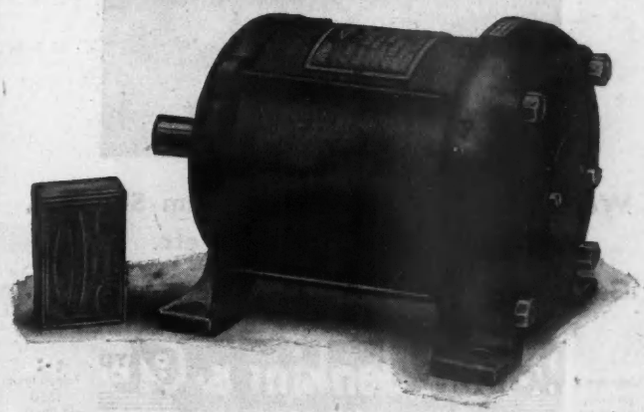

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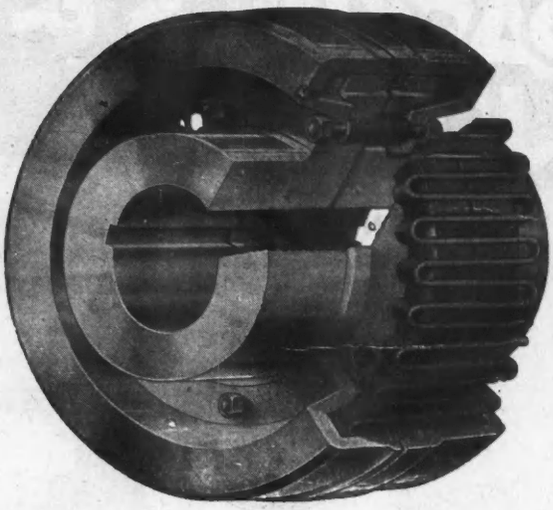

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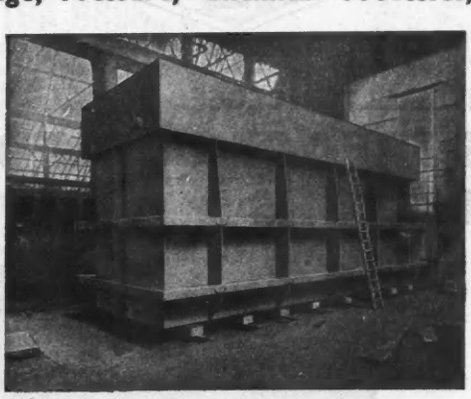

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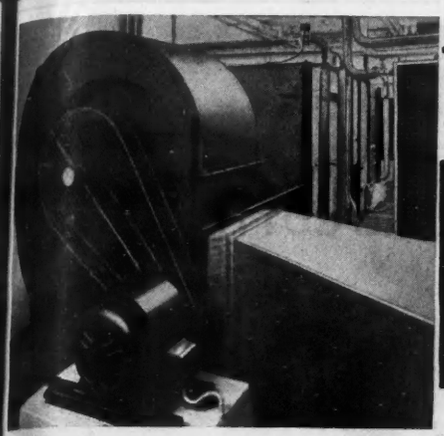

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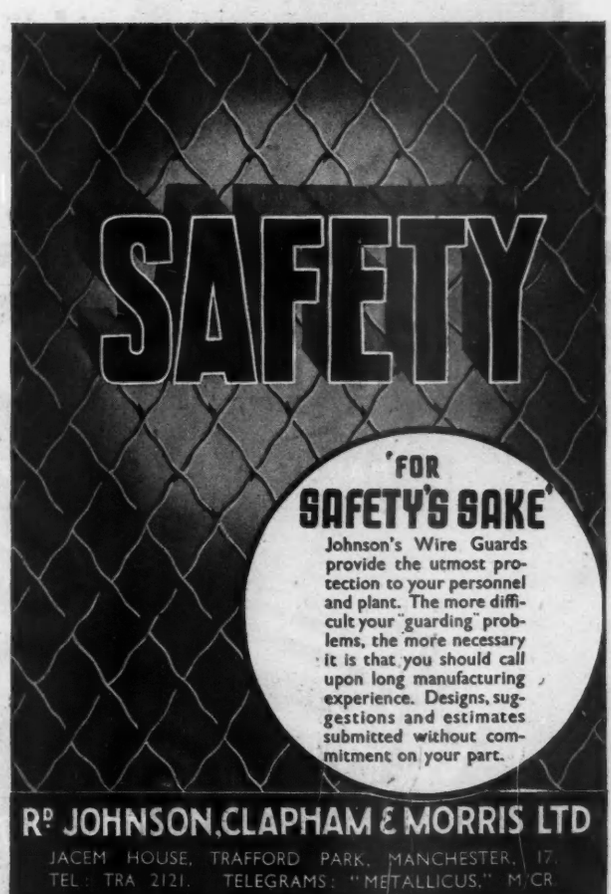
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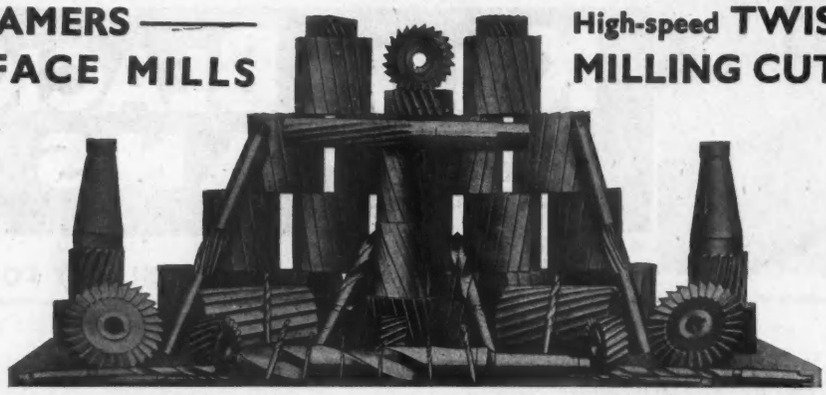

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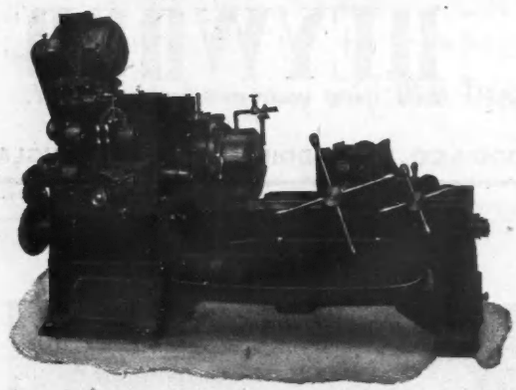

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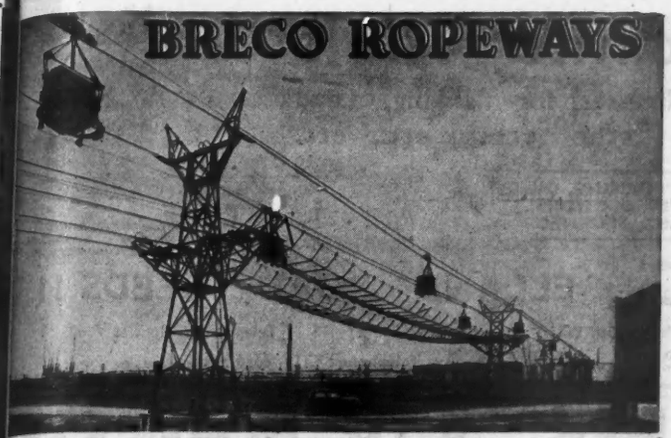

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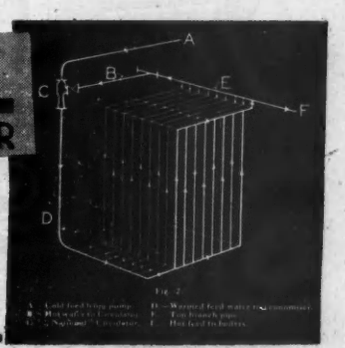

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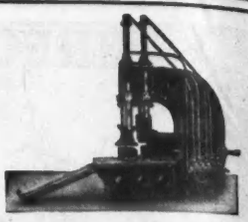

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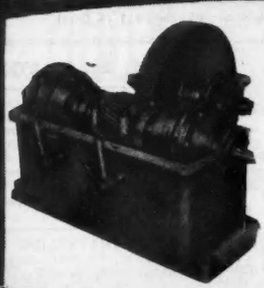

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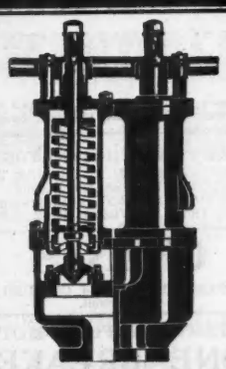

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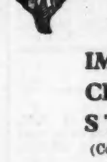

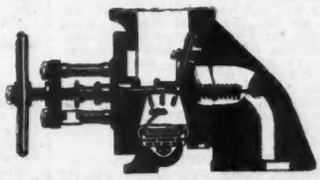

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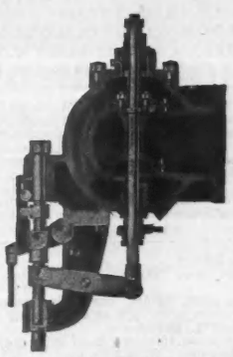

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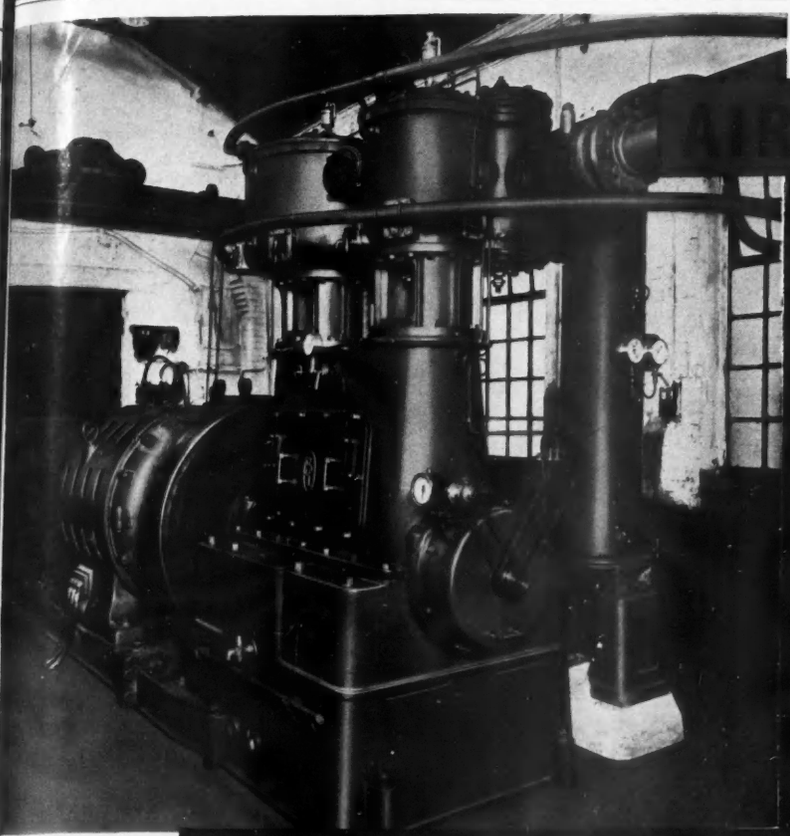

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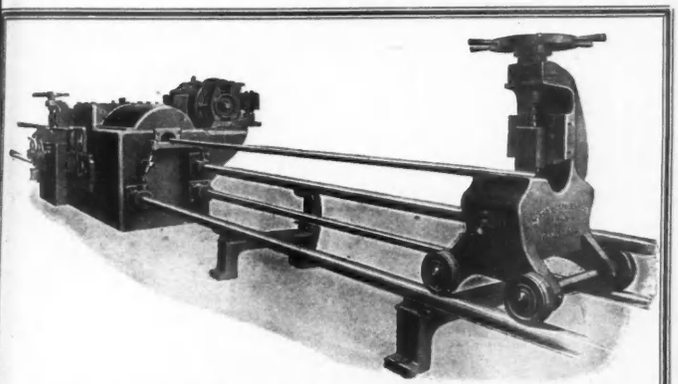

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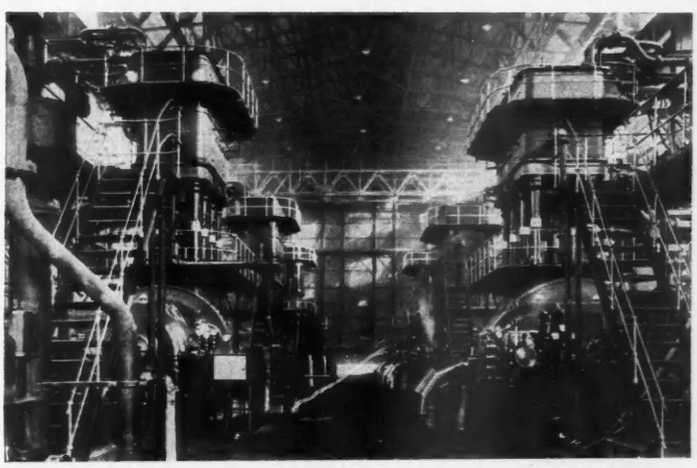

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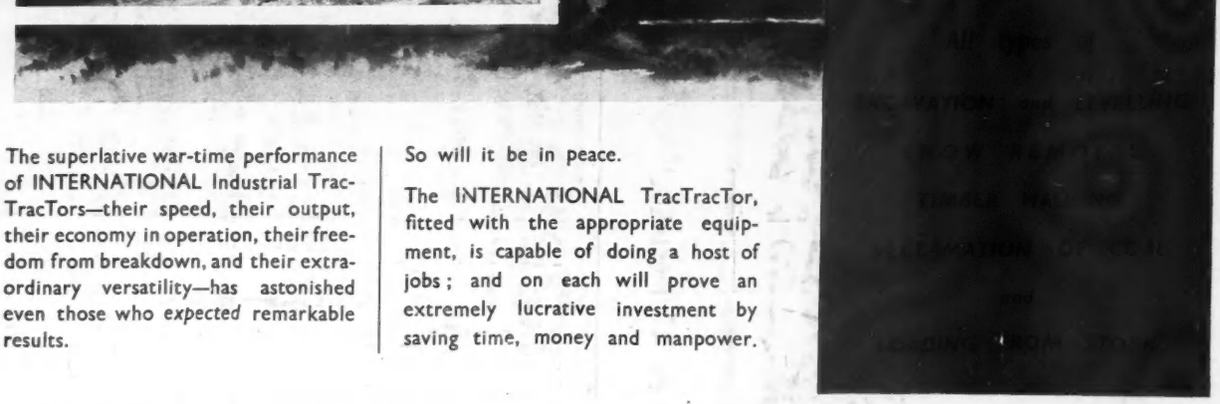

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